



Dust particulates and asbestiform material, Savage River Mines, Savage River

by M. E. Curtain

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INTRODUCTION

In early March 1991 an unidentified rock sample from an anonymous source was received at the then Division of Mines and Mineral Resources for asbestos identification.

The sample was crushed and analysed using microscopic and X-Ray Diffraction techniques and was found to contain magnetite and an asbestiform material.

On 28 March 1991 Mrs Christine Milne MHA contacted the Department and confirmed that the sample was from Savage River Mines, Savage River. She appeared to believe that the mine should be closed forthwith, despite arguments for monitoring, testing and scientific sampling. The outcome was that Mrs Milne agreed to provide additional samples. A sample was collected on 4 April 1991 and appeared to be of drill hole cuttings.

The then Minister for Resources and Energy, the Hon. Michael W. Weldon MHA, was briefed on the matter on 4 April 1991.

On 15 May 1991 the then Minister was informed that Mrs Milne had also sent samples to Worksafe Australia for analysis. Worksafe identified the presence of tremolite, a form of asbestos.

Requests were made of Mrs Milne and her office to identify the area where the samples were taken at the mine, but without success.

The sample received by the Division of Mines and Mineral Resources was also analysed and it was concluded that possibly a mixture of tremolite and anthophyllite was present.

In July 1991 the Minister directed that the Mines Inspectorate instigate an investigation into the matter.

Over the period 1–8 September 1991 members of the Mines Inspectorate conducted an occupational health survey at Savage River Mines, Savage River. The survey indicated that fibrous amphibole asbestos was present in nearly all locations sampled, mainly as tremolite and related amphiboles. Serpentine was also identified in several samples, probably as antigorite, while some were also fibrous or asbestiform.

DEFINITION

According to Worksafe Australia — National Occupational Health and Safety Commission's publication *Asbestos — Code of Practice and Guidance Notes*, August 1988:—

- Asbestos is defined as the fibrous form of mineral silicates belonging to the serpentine and amphibole groups of rock-forming minerals, including actinolite, amosite (brown asbestos), crocidolite (blue asbestos), chrysotile (white asbestos), tremolite, or any mixture containing one or more of these
- Fibre is a particle of asbestos with a diameter of less than 3 µm and greater than 5 µm in length, with a length to diameter ratio of greater than 3:1

EXPOSURE STANDARDS

The publication of Worksafe Australia — National Occupational Health and Safety Commission's *Exposure Standards for Atmospheric Contaminants in the Occupational Environment* (October 1991, 2nd Edition) states for asbestos.

- Asbestos is the generic name used for the fibrous form of a group of naturally occurring mineral silicates of the serpentine and amphibole series including the fibrous serpentine mineral chrysotile (white asbestos) and the amphiboles known in fibrous forms as actinolite, amosite (brown asbestos), anthophyllite, crocidolite (blue asbestos) and tremolite.

The average fibre concentration of the air breathed by a worker throughout a working shift, as calculated from measurements made in accordance with the National Commission's Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Dust, should not exceed the values in the following table.

Type of Asbestos	Time Weighted Exposure (TWA) Fibres per mL of air
Crocidolite (blue asbestos)	0.1
Amosite (brown asbestos)	0.1
Chrysotile (white asbestos)	1.0
Other forms	0.1
Any mixture of these, or where the composition is unknown	0.1

The National Occupational Health and Safety Commission supports the principle that exposure to airborne asbestos should be kept as low as achievable, and in any case below the specified exposure standards.

CHRONOLOGICAL EVENTS

The existence of fibrous asbestiform minerals at Savage River has been known for many years — the host rocks for the iron ore are mainly of the amphibole group, which includes asbestos minerals particular of the tremolite – actinolite series.

Savage River Mines claimed that early test work showed that the asbestiform minerals did not exhibit the fraying and branching tendency of defined asbestotic materials.

To assure management and employees of the nature of the material the Australian Mineral Development Laboratories (AMDEL) were contracted to conduct a sampling programme at Savage River Mines in 1984–85.

AMDEL Report — (Dr David Cruickshanks-Boyd, summary)

Rock and dust samples were collected over various periods from November 1984 to March 1985.

All sampling was committed to fine weather only and was stopped during adverse weather conditions.

Analysis of the rock samples indicated elongated amphibole minerals of the tremolite-actinolite series. Microscopic examination of pulverised material and dust samples showed masses of fine needles, some of which were less than 3 µm in diameter. However, the needle-like amphibole is not defined as asbestos, as the needles do not show the characteristic fraying and branching tendency of the fibrous, asbestos form of tremolite. Some samples also contained elongated serpentine material being a rare form of antigorite. AMDEL concluded that the elongated material was not asbestos.

Preliminary fibre monitoring revealed asbestiform fibres above the level of 0.1 fibres per mL in several mine locations.

AMDEL's analytical methods included:-

- Sampling
 - bulk samples rocks
 - airborne asbestos dust using the NH & MRC Filter Method
- Microscopic Examination
 - stereo microscope
 - polarising microscope
 - Magnification 50 and 200 times normal
- X-Ray Diffraction (XRD)

ACTU-VTHC Occupational Health & Safety Unit Report (Ms Noni Holmes, Summary)

In June 1985 this unit conducted a worksite inspection of the Savage River iron ore mines following a Government Analyst's report and AMDEL's preliminary fibre monitoring, which indicated levels of 0.1 fibre/mL in several locations. The 0.1 fibre/mL is the Maximum Allowable Concentration (MAC) in the ACTU - Health and Safety Bulletin No. 42 *Guidelines on Asbestos*.

The inspection was conducted over one day and was confined to visual observations and information gained from union delegates and management.

No scientific investigation, sampling or monitoring was carried out.

The report was written, from the one day inspection, and included all aspects of occupational health and safety from asbestos to dust, fumes, heat, noise, vibration etc.

Although conclusions and recommendations were made, no valid points could be ascertained on the type, concentration and source of asbestiform materials from the report.

Tasmanian Government Analyst (Memo)

In September 1985 the Tasmanian Government Analyst confirmed that a previous sample submitted by the FEDFA in September 1984 was actually tremolite. Originally he

reported it as chrysotile (white asbestos). The method of analysis is unknown.

Savage River Mines

After AMDEL's report Savage River Mines in 1985 took the view that none of the asbestiform materials located at the mine were identified as being toxic.

However, in order to control any possible problems recommendations were made, including instructions from the Inspector of Mines, to ensure all processes likely to generate dust from these materials were carried out wet. This included the prohibition of dry drilling of blast holes, provision of dust masks, and improved sealing of cabins and drill rigs.

Worksafe Australia — National Institute of Occupational Health and Safety Report (Rogers and Conaty, Summary)

In May 1991 Worksafe Australia identified a sample of drilled iron ore material, submitted by Mrs Christine Milne and alleged to have come from the Savage River Mine, as containing fibrous material.

The mineral fibres were identified (Rogers and Conaty) as tremolite (asbestos) with smaller amounts of poorly differentiated magnesium silicates — serpentine (not chrysotile or white asbestos). Electron micrographs and EDAX spectra showed examples of typical fibres found in the sample.

Worksafe's analytical methods included:-

- Polarised Light Microscopy using Dispersion Staining Techniques.
- Transmission Electron Microscopy (TEM) and micrographs.
- Energy Dispersive X-Ray Analysis (EDAX)
- Scanning Area Electron Diffraction (SAED) patterns.
- Magnification 6300, 8000 and 22 000 times normal.

Division of Mines and Mineral Resources (Memo, R. S. Bottrill)

In May 1991 the Division identified a sample purported to have come from Savage River Mines as being of the "Amosite type", and concluded that a mixture of tremolite and anthophyllite possibly existed.

Division of Mines and Mineral Resources (Department of Mines) — Mines Inspection Branch's Survey

Over the period of 1-8 September 1991 members of the occupational health unit of the Mines Inspection Branch conducted an occupational health dust sampling survey at the mine during inclement weather conditions.

The survey indicated that fibrous amphibole asbestos was present in bulk rock samples, drill cuttings and in airborne dust around the mines and mill. The asbestos was present mainly as tremolite and related amphiboles. Serpentine was also identified in several samples, probably as antigorite, while some samples were also fibrous or asbestiform.

Fibre monitoring revealed asbestiform fibres were between 0.05 fibres/mL to less than 0.01 fibres/mL. These levels are below the recommended Worksafe Australia exposures standard of 0.1 fibre/mL.

Division of Mines and Mineral Resources analytical methods included:—

- Sampling
 - Bulk samples, rocks and drill cuttings
 - Airborne dust using the Membrane Filter Method prescribed by Worksafe Australia (August 1988)
- Polarised light microscopy
- X-Ray diffractometry
- Scanning electron microscopy and micrographs
- Magnification 2020, 8050, 10 000, and 20 000 times normal

DISCUSSION

The events described above raise two issues:

1. The different interpretation that is given to define what is an asbestos fibre, and
2. The degree of toxicity exhibited by the various types, physical forms of fibres.

Issue 1

- Cruickshanks-Boyd (1985) considered that most of the amphibole and tremolite “fibres” at Savage River Mines are cleavage fragments rather than true fibres, and the asbestos definitions are overly restrictive.

He stated that the material was not asbestos, but was accurately described as elongated tremolite crystals and elongated antigorite crystals.

- A number of researchers have recognised that the non-asbestos varieties of the amphibole and serpentine minerals are widespread in occurrence, and that these minerals will readily cleave into fragments whose size meets the definition of “fibre” used in the Membrane Filter Method for estimating exposure to airborne asbestos dust (Campbell, 1977; Lee, Lally and Fisher, 1977).
- The above points conflict with Worksafe Australia’s findings of Rogers and Conaty, who state that the sample (supplied by Mrs Milne and presumed to be from Savage River) contained mineral fibres which were identified as tremolite (asbestos) with smaller amounts of poorly differentiated serpentine.

Rogers and Conaty used more sophisticated techniques of analyses than AMDEL, viz TEM, EDAX and SAED. Their magnification ratios were 6300, 8000 and 22 000 times normal compared with AMDEL’s 50 and 200 times normal.

- The first two points also conflict with the Department of Mines analyses, which used X-Ray Diffraction, Scanning Electron Microscopy and micrographs with an order of magnification of 2020, 8050, 10 000 and 20 000 times normal, and which identified tremolite as definitely being present as a fibre according to Worksafe Australia’s definition.

Issue 2

- Researchers have postulated that the toxicity of an asbestos fibre varies with its physical form and size, particularly with length and diameter.

Stanton and Layard (1977) stated that the greatest risk is with particles greater than 8 µm long and less than 0.25 µm diameter. Similar statements have been made by Muir (1976) and Pott (1978).

The tremolite fibres identified from the survey at Savage River Mines were in the order of 6 µm long and 2 µm diameter, and according to the above researchers are likely to be of a lower health hazard.

Nevertheless current standards according to the principles quoted under *Definitions and Exposure Standards* of this report must apply.

OCCUPATIONAL HEALTH SURVEY SAVAGE RIVER MINES

SEPTEMBER 1991

1. INTRODUCTION

The Mines Inspectorate conducted an occupational health dust sampling survey at Savage River Mines between 1 and 8 September 1991 following a request from the Minister for Resources and Energy. This was in response to a claim initiated by Mrs Christine Milne (MHA) regarding the finding of asbestos-type minerals allegedly sampled at Savage River.

2. PROLOGUE

Asbestiform minerals have been known to exist at Savage River Mines since the mine started. Previous surveys (AMDEL, 1985) identified the amphibole tremolite as the main form present. Antigorite, a serpentine material, was also found.

AMDEL also stated that the material was not asbestos but elongated tremolite crystals and elongated antigorite crystals.

Rogers and Conaty (1991) analysed an alleged sample from Savage River Mines and concluded that the fibres present were the amphibole tremolite, with some poorly differentiated serpentine.

3. SUMMARY AND CONCLUSIONS

- 3.1 The Inspectorate's September survey indicated that fibrous amphibole asbestos was present in nearly all locations sampled, mainly as tremolite and related amphiboles. Serpentine was also identified in several samples, probably as antigorite, while some were also fibrous or asbestiform.
- 3.2 All drill cuttings contained asbestos fibre, probably tremolite or associated amphiboles. Most of the rock samples also contained fibrous amphibole.
- 3.3 Amphibole was detected by XRD on many of the airborne dust filters, indicating that asbestos was probably present. This was confirmed by microscopic examination of a number of membrane filters revealing the presence of asbestos fibre. This was further confirmed by SEM (Scanning Electron Microscopy) where the exact size and characteristics were determined and recorded on photographs.
- 3.4 A small number (15) of filter samples were counted for fibres by the Government Analyst and also the Department of Mines.

The fibre counts, in accordance with the Filter Membrane Method (NOHSC), were found to be

between <0.01 and 0.05 fibres per millilitre. The levels are below the Exposure Standards of 0.1 fibre/ml for amphibole asbestos as stated by NOHSC *Exposure Standards for Atmospheric Contaminants in the Occupational Environment* (October 1991).

- 3.5 The health risks at this exposure level are low, however certain factors must be considered:
 - (a) The monitoring was conducted in damp, rainy conditions which would represent the lowest exposure to any form of dust or fibre;
 - (b) The main activity at the North Pit was restricted to the removal of overburden and not mining the orebody;
 - (c) Drilling activity was minimal; and
 - (d) Industrial strikes prevailed on a number of days.

These factors suggest that further sampling is required, particularly during a dry period and when the mine is at or near full production.

- 3.6 An attempt should be made to establish the health hazards associated with various fibrous forms.

Some researchers have stated that the toxicity of an asbestos fibre varies with its size, particularly with length and width.

Stanton and Layard (1978) stated that the greatest risk is with particles greater than 8 μm long and less than 0.25 μm diameter.

The tremolite fibres identified from the survey were in the order of 6 μm long and 2 μm diameter and likely to be of a lower health hazard.

Nevertheless current standards prescribed by NOHSC (Worksafe Australia) apply.

- 3.7 α -quartz concentrations were well below the existing TLV-TWA of 0.2 mg/m^3 .
- 3.8 Inspirable dust was well below the prescribed level of 10 mg/m^3 . However it was interesting to note that drill rig 45R2 at the Southern Lens had several high readings, one (47.79 mg/m^3) being well above the TLV-TWA; this sample was suspect.

Another sample taken inside the Crusher Cab was below the limit but high enough (3.44 mg/m^3) to be

of interest because it was collected inside the sealed(?) cab.

Other factors as mentioned in Item 3.5 would also need to be considered.

4. SAMPLING

4.1 The survey was conducted over 24 hours a day for 8 days during inclement weather, except for 7 September 1991 when fine conditions were experienced.

4.2 The sampling was originally intended for the drilling operations but was extended to other classifications due to circumstances that prevailed at the mine.

4.3 Monitoring was determined at the following locations and equipment:

<i>Location</i>	<i>Equipment</i>
Centre Deposit	PH1 shovel Haulage trucks 40R4 drill
South Lens	Front end loader Haulage trucks 45R2 drill
North Deposit	PH3 shovel PH4 shovel 40R1 drill 45R1 drill
Crusher	Inside cab Outside cab
Mill	
Maintenance shop	

4.4 The samples obtained were:

Bulk Samples (24)	
Rock Samples	Centre Deposit (6) South Lens (8) North Deposit (2)
Drill Cuttings	Centre Deposit (6) North Deposit (2)

Inspirable Dust Samples (52)
Centre Deposit
South Lens
North Deposit
Crusher
Maintenance Shop
Mill

Asbestos Samples (Respirable Fibre)
(NOHSC Method) (61)
Centre Deposit
South Lens
North Deposit
Crusher
Mill

4.5 The samples were analysed for:

Bulk Samples — see Appendices 1 and 7

α -quartz, asbestos, magnetite, talc, chlorite, feldspar and other minor components by XRD and microscopy.

Inspirable Dust Samples — see Appendix 2

α -quartz, amphibole, fibre and weight by XRD, microscopy and balance. (Only 26 samples checked for fibre)

Asbestos Samples — see Appendix 3

Asbestos fibre counts, NOHSC Membrane Filter Method by the Government Analyst and Department of Mines. (Only 15 samples counted)

A further three samples were examined by SEM (Scanning Electron Microscopy).

5. STANDARDS

5.1 The following TLVs or Exposure Standards set by Worksafe Australia (NOHSC) apply:

<i>Contaminant</i>	<i>TLV-TWA Standard</i>
α -quartz (respirable)	0.2 mg/m ³
α -quartz (proposed by Worksafe)	0.1 mg/m ³
Inspirable dust	10 mg/m ³
Chrysotile	1.0 fibre/ml
Crocidolite	0.1 fibre/ml
Amosite	0.1 fibre/ml
Other forms of asbestos (viz. tremolite)	0.1 fibre/ml
Any mixture of these, or where the composition is unknown	0.1 fibre/ml

Note: Exposure to airborne asbestos should be kept as low as achievable, and in any case below the specified exposure standards.

6. RESULTS

6.1 All the results are presented in Appendices 1, 2, 3, 4, 5, 6, 7 and attached photographs.

- Appendix 1:** Results of Petrographic and XRD Analyses of Bulk Samples.
- Appendix 2:** Summary data for membrane filters – inspirable dust.
- Appendix 3:** Asbestos fibre counts on membrane filters.
- Appendix 4:** Particulate and asbestos monitoring at various locations.
- Appendix 5:** Asbestos sampling as per the filter membrane method and fibre counts.

Appendix 6: Drilling samples indicating inspirable dust, presence of amphibole, fibre % and fibre count.

Appendix 7: Bulk sample locations in the Centre pit, South lens and North pit.

Photographs: Scanning electron microscope photographs of asbestos fibres.

- 6.2 Brief interpretation of the results: as mentioned previously all asbestos fibre counts are below the exposure standards for amphibole asbestos.

Central Deposit

PH1 shovel: – fibre and amphibole material present.

Trucks: – fibre and amphibole material present.
– Truck 33, diesel exhaust entering cab.

Drill 40R4: – fibre and amphibole material present.

South Lens

Drill 45R2: – fibre, amphibole and some antigorite present.
– high inspirable dust.

North Deposit

Drill 45R1: – fibre present.

Drill 40R1: – high fibre and amphibole present.
– slightly high inspirable dust.

PH3 shovel: – no sample examined.

PH4 shovel: – low fibre count.

Crusher

– fibre and amphibole present.
– slightly high inspirable dust inside cabin.

Mill

– fibre and amphibole present.

7. COMMENTS

- 7.1 Monitoring was conducted during adverse weather conditions when it was mainly raining. The amount of generated dust and fibrous material would be at its lowest level.
- 7.2 The mine was not operating at normal capacity due to rolling strikes, minimal drilling operations and removing overburden at the North Deposit.
- 7.3 The Crusher Cab could be up-graded, the fan does not work and the doors are out of alignment.
- 7.4 The pattern of the crusher water sprays is inconsistent.
- 7.5 The cabin filtering system on Truck 33 was not working effectively, the membrane filter indicating high amounts of carbonaceous material from the diesel exhaust entering the cabin.
- 7.6 Details of the mining operations and weather conditions have been noted but are not included in this report.

8. RECOMMENDATIONS

- 8.1 A further survey, possibly over one or two shifts per day, is required when the mine is operating at or near normal capacity and when the weather is dry; and preferably when mining the North Deposit ore body.
- 8.2 A larger number of samples needs to be counted for fibre, and further work using the scanning electron microscope is required to characterise the fibres.
- 8.3 An attempt should be made to establish the health hazards associated with the various fibrous forms.
- 8.4 High inspirable dust readings in the drilling machines and crusher cabin indicate improved maintenance and housekeeping is required in these areas.
- 8.5 Cabin air filters of haulage trucks need to be regularly maintained.
- 8.6 A complete noise survey is required.

M. E. Curtain

INDUSTRIAL CHEMIST

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[15 May 1992]

APPENDIX 1

Results of petrographic and XRD analyses of bulk samples, Savage River Mines

Reg. No.	Field No.	Pit Location No.	Rock type	Quartz	Amph.	Serpent.	Chl	Mag	Talc	Fsp	Others
<i>Mine Site — Centre D</i>											
G402101	C1	8	Drill cuttings		3,F		4	4	3		Py
G402102	C2	9	Drill cuttings		3,F		4	4	2		Py
G402103	C3	10	Drill cuttings		3,F		4	4	2		Py
G402104	5 CLD 22	5	Drill cuttings		4,F		4	2	2	2	Mica
G402105	6 CLD	6	Drill cuttings		3,F		4	4	2		
<i>Mine Site — North D</i>											
G402106	1NDED	1	Drill cuttings	3	1,F		4	2	2	2	
G402107	2NDDE	2	Drill cuttings	3	1,F		4	2		3	Dol, Cal
<i>Mine Site — South Lens</i>											
G402108	South Lens	2A	Chl-mag schist			3,F	4	4	2		Py
<i>Mine Site — Centre D</i>											
G402109	Central D	6A	Tr schist		4,F		2	2	3		
G402110	1CL22-60W	1	Bt schist		3,F		4	1		3	Mica, Py, Tur
G402111	2CL22-110W	2	Chl-tr schist		4,F		4	2			Py
G402112	3CL22-180W	3	Tlc-tr schist		3,F		4	2			Py
G402113	7CL22	7	Amphibolite		4,F		4		2	2	Py
<i>Mine Site — South Lens</i>											
G402114	1SLW (W-SL)	1	Magnetite ore				3	4			Py
G402115	2SLW	2	Chl-amphibolite		3,F		4	3			Py
G402116	3SLW	3	Ep-amphibolite		4,F		3	1		4	Dol, Ep, Py
G402117	4SLW	4	?mixture		3,F	2,F	4	2			Mica, Py
G402118	5ASLW	5A	Amphibolite	3	4,F		3	3	2	3	Mica, Py
G402119	6SLW	6	Amphibolite		4,F		4	2			Mica, Py, Ep
G402120	5BSLW	5B	Serpentinite			4		3	3		Py, Dol
<i>Mine Site — North D</i>											
G402121	3NDE	3	Chl-fsp schist	3			4			4	Cal, mica, py
G402122	4NDE	4	Ep-amphibolite	3	3,F		4	1		3	Ep, Cal, Py, mica
<i>Mine Site — Centre D</i>											
G402123	5CLD	4	Srp-breccia		3,F	4	3	3	3		Calcite, Tur

1: Present: 1%

2: trace: ~1-5%

3: minor: ~5-20%

4: major: >~20%

Blank: not detected

F: fibres present

Mag: magnetite

Chl: chlorite

Tlc: talc

Py: pyrite

Fsp: feldspar

Bt: biotite

Ep: epidote

Tr: tremolite

Cal: calcite

Dol: dolomite

Srp: serpentinite

Tur: tourmaline

APPENDIX 2

Savage River Mines — Summary data for membrane filters, inspirable dust

Reg. No.	Location	Site	Dust Weight	α -quartz	Amphibole	Fibre %
D0718	Drill 45R1	North pit	0.69	0.01		2
D0719	PH1 Shovel	Central Deposit	0.56	0.01		1
D0720	PH3 Shovel	North pit	0.42	0.03		ne
D0721	Drill 40R1	North pit	2.03	0.05	Y	5
D0722	Truck S4	Central Deposit	0.74	0.01		ne
D0723	Crusher Cab	Crusher	0.28	<		ne
D0724	PH1 Shovel	Central Deposit	0.45	<		ne
D0725	Truck 49	Central Deposit	0.38	<		ne
D0726	Truck 35	Central Deposit	0.52	<		ne
D0727	Outside cab	Crusher	0.48	<		ne
D0728	Truck 49	Central Deposit	0.41	0.01		ne
D0729	PH1 Shovel	Central Deposit	0.37	0.01		1
D0730	Crusher Cab	Crusher	0.83	0.02	Y	1
D0731	FE Loader	South Lens	0.55	0.02		ne
D0732	Truck 33	Central Deposit	0.46	0.01		ne
D0733	PH1 Shovel	Central Deposit	0.43	<		ne
D0734	PH4 Shovel	North pit	0.64	<		<1
D0735		Maintenance shop	0.26	<		ne
D0736	Truck 44	Central Deposit	0.32	0.02		1
D0737	PH1 Shovel	Central Deposit	0.43	0.02	Y	3
D0738	Drill 45R1	North pit	0.25	<		ne
D0739	Truck 37	South Lens	0.42	0.02		ne
D0740	PH1 Shovel	Central Deposit	0.31	<		ne
D0741	Drill 45R2	South Lens	4.92	0.01	Y	2
D0742	Outside cab	Crusher	0.87	<	Y	<1
D0743	Drill 45R1	North pit	0.63	<		ne
D0744	Centre ground floor	Maintenance shop	0.40	<		ne
D0745	Outside cab	Crusher	0.55	<		ne
D0746	Drill 45R2	South Lens	7.75	<	Y	3
D0747	Truck 49	Central Deposit	0.32	<		ne
D0748	PH1 Shovel	Central Deposit	0.61	<		ne
D0749	Crusher Cab	Crusher	3.44	<		ne
D0750	Outside cab	Crusher	3.10	0.01	Y	ne
D0915	Floor 2 centre rail	Mill				3
D0916	Floor 1 2nd feed	Mill				ne
D0917	Floor 1 1st feed	Mill				1
D1029	PH1 Shovel	Central Deposit	?<0.1	<	Y	ne
D1030	Truck 43	Central Deposit	0.17	<	Y	ne
D1031	Floor 2 middle rail	Mill	0.38	<		ne
D1032	Drill 45R2	South Lens	47.79	too loose	Y	ne
D1033	PH3 Shovel	North pit	0.68	0.01		ne
D1035	Drill 45R2, deck	South Lens	1.23	<	Y	1
D1036	Drill 45R2, cab	South Lens	0.46	0.02	Y	<1
D1037	PH3 Shovel	North pit	0.53	0.07		ne
D1038	Drill 40 R4 cab	Central Deposit	0.36	0.02	Y	1
D1039	Floor 1 centre	Mill	0.29	0.02	Y	2
D1040	Drill 40R4 outside	Central Deposit	0.80	<		1
D1041	Outside cab	Crusher	0.09	0.04		ne
D1042	Outside cab	Crusher	0.25	0.04		ne
D1043	Drill 40R1 cab	North pit	3.83	0.02	Y	5
D1044	Outside cab	Crusher	0.83	0.01	Y	ne
D1045	Drill 40 R4 cab	Central Deposit	1.15	0.01	Y	ne
D1046	Truck 42	Central Deposit	0.71	0.01	Y	1
D1047	Floor 1 exit, centre ball mill	Mill	0.45	<	Y	ne
D1048	Floor 1 entry, centre ball mill	Mill	0.26	0.01		ne

<: <0.01 mg;

Y: amphibole present;

ne: not examined

APPENDIX 3

Summary data for fibre counts on membrane filters, Savage River Mines

Reg. No.	Location	~No. fibres/filter	Flow rate (L/min)	Sampling time (min)	Fibres/mL	Counter
D0903	Outside crusher		1.059	375	<0.01	GA
D0905	Mill, N side	7119	1.023	480	0.02	RSB
D0913	Crusher Cab	10861	1.004	350	0.03	RSB
D0914	PH Shovel 1	872	0.885	310	<0.01	RSB
D0920	PH Shovel 3		1.066	305	Overloaded	GA
D0924	Drill 45R2 deck		1.111	335	Overloaded	GA
D0926	Drill 45R2	11708	1.165	335	0.03	GA
D0931	Drill 40R4	5865	1.029	285	0.02	GA
D0932	Drill 40R4		1.049	285	Overloaded	GA
D1005	Drill 40R1		1.051	320	Overloaded	GA
D1009	Crusher cab	11900	1.189	305	0.03	RSB
D1015	PH Shovel 1		1.184	300	<0.01	GA
D1019	PH Shovel 1	18176	1.262	300	0.05	RSB
D1024	Drill 45R1	13504	1.023	330	0.04	GA
D1026	PH Shovel 4		1.165	355	<0.01	GA

RSB: R. Bottrill

GA: Government Analyst laboratories

APPENDIX 4

Particulate and asbestos monitoring, Savage River Mines

Location	Sample No.	Contaminant	Date (September, 1991)						Fibre (%)	Comments
			2/9 (mg/m ³)	3/9 (mg/m ³)	4/9 (mg/m ³)	5/9 (mg/m ³)	6/9 (mg/m ³)	7/9 (mg/m ³)		
Central Deposit										
PH 1 shovel	719	INSP	0.56						1	
Truck S4	722	INSP	0.74						ne	
PH 1 shovel	724	INSP		0.45					ne	
Truck 49	725	INSP		0.38					ne	
Truck 35	726	INSP		0.52					ne	
Truck 49	728	INSP		0.41					ne	
PH 1 shovel	729	INSP		0.37					1	
Truck 33	732	INSP		0.46					ne	Black carbonaceous material from diesel exhaust entering cab
PH 1 shovel	733	INSP		0.43					ne	
Truck 44	736	INSP		0.32					1	
PH 1 shovel	737	INSP			0.43				3	Amphibole
PH 1 shovel	740	INSP			0.31				ne	
Truck 49	747	INSP				0.32			ne	
PH 1 shovel	748	INSP				0.61			ne	
PH 1 shovel	1029	INSP					-0.19		ne	Amphibole. Ashed weight -ve
Truck 43	1030	INSP					0.17		ne	Amphibole
Drill 40R4 cab	1038	INSP						0.36	1	Amphibole
Drill 40R4 outside	1040	INSP						0.80	1	
Drill 40R4 cab	1045	INSP						1.15	ne	Amphibole
Truck 42	1046	INSP						0.71	1	Amphibole
South Lens										
F.E.Loader Rodney Johnson	731	INSP		0.55					ne	
Truck 37	739	INSP			0.42				ne	
Drill 45R2	741	INSP			4.92				2	Amphibole
Drill 45R2	746	INSP				7.75			3	Amphibole
Drill 45R2	1032	INSP					47.79		ne	Amphibole
Drill 45R2 deck	1035	INSP						1.23	1	Amphibole
Drill 45R2 cab	1036	INSP						0.46	<1	Amphibole
North Pit										
Drill 45R1	718	INSP	0.69						2	
PH 3 shovel	720	INSP	0.42						ne	
Drill 40R1	721	INSP	2.03						5	Amphibole
PH 4 shovel	734	INSP	0.64						<1	
Drill 45R1	738	INSP	0.25						ne	
Drill 45R1	743	INSP	0.63						ne	
PH 3 shovel	1033	INSP					0.68		ne	
PH 3 shovel	1037	INSP						0.53	ne	

Location	Sample No.	Contaminant	Date (September, 1991)					Fibre (%)	Comments
			2/9 (mg/m ³)	3/9 (mg/m ³)	4/9 (mg/m ³)	5/9 (mg/m ³)	6/9 (mg/m ³)		
Drill 40R1 cab	1043	INSP					3.83	5	Amphibole
<i>Crusher</i>									
Crusher cab	723	INSP		0.28				ne	
Outside cab	727	INSP		0.48				ne	
Crusher cab	730	INSP		0.83				1	Amphibole
Outside crusher	742	INSP			0.87			<1	Amphibole
Outside crusher	745	INSP				0.55		ne	
Crusher cab	749	INSP				3.44		ne	
Outside crusher	750	INSP				3.10		ne	Amphibole
Outside crusher	1041	INSP					0.09	ne	
Outside crusher	1042	INSP					0.25	ne	
Outside crusher	1044	INSP					0.83	ne	Amphibole
<i>Mill</i>									
2nd floor middle rail	1031	INSP	0.38					ne	
2nd floor centre rail	915	INSP	-					3	
1st floor 2nd feed	916	INSP	-						
1st floor 1st feed	917	INSP	-					1	
1st floor centre	1039	INSP		0.29				2	Amphibole
1st floor exit centre ball mill		INSP		0.45				ne	Amphibole
1st floor entry centre ball mill		INSP		0.26				ne	

ne = not examined

APPENDIX 5

Asbestos sampling, Savage River Mines

Location	Sample No.	Date (September, 1991)						Fibre (fibres/mL)
		2/9	3/9	4/9	5/9	6/9	7/9	
<i>Central Deposit</i>								
PH 1 shovel	2	*						
Truck 34	4	*						
Truck 49	6		*					
Truck 35	7		*					
PH 1 shovel	10		*					
Truck 35	11		*					
PH 1 shovel	15		*					<0.01
PH 1 shovel	19		*					0.05
Truck 49	20		*					
Truck 44	22			*				
PH 1 shovel	23			*				
PH 1 shovel	904				*			
PH 1 shovel	906				*			
Truck 43	911					*		
PH 1 shovel	914					*		<0.01
Truck 42	922					*		
Fagans Cat loader	923					*		
Drill 40R4 cab	928						*	
Drill 40R4 cab	931						*	0.02
Drill 40R4 deck	932						*	Overloaded with dust
<i>Southern Lens</i>								
F.E.loader 292C	13		*					
Truck 36	14		*					
Truck 37	21		*					
Drill 45R2	27			*				
Drill 45R2	907				*			
Drill 45R2	919					*		
Drill 45R2	924					*		Overloaded with dust
Drill 45R2 deck	926						*	0.03
Drill 45R2 cab	927						*	
Drill 45R2 cab	925						*	
<i>North Pit</i>								
Drill 45R1	1	*						
PH 3 shovel	3	*						
Drill 40R1	5	*						Overloaded with dust
PH 4 shovel	17		*					
Drill 45R1	24			*				0.04
Drill 45R1	25			*				
PH 4 shovel	26			*				<0.01

Location	Sample No.	Date (September, 1991)						Fibre (fibres/mL)
		2/9	3/9	4/9	5/9	6/9	7/9	
PH 3 shovel	920					*		Overloaded with dust
PH 4 shovel	921					*		
PH 3 shovel	925						*	
Drill 40R1	934						*	
Crusher								
Outside crusher	8		*					
Crusher cab	9		*					0.03
Outside crusher	12		*					
Outside crusher	28			*				
Outside crusher	903			*				<0.01
Crusher cab	908				*			
Outside crusher	912					*		
Crusher cab	913					*		0.03
Crusher outside	918					*		
Crusher outside	933						*	
Mill								
Stockpile D8	16		*					
Maintenance shop	18		*					
Ball mill	901				*			
North Side mill	902				*			
North Side mill	905				*			0.02
Rear 1st mill	909				*			
Near 1st mill	910				*			
2nd floor north	915					*		
1st floor 2nd feed	916					*		
1st floor 1st feed	917					*		
1st floor 2nd feed	929						*	
1st floor 1st feed	930						*	

* = sampled

APPENDIX 6

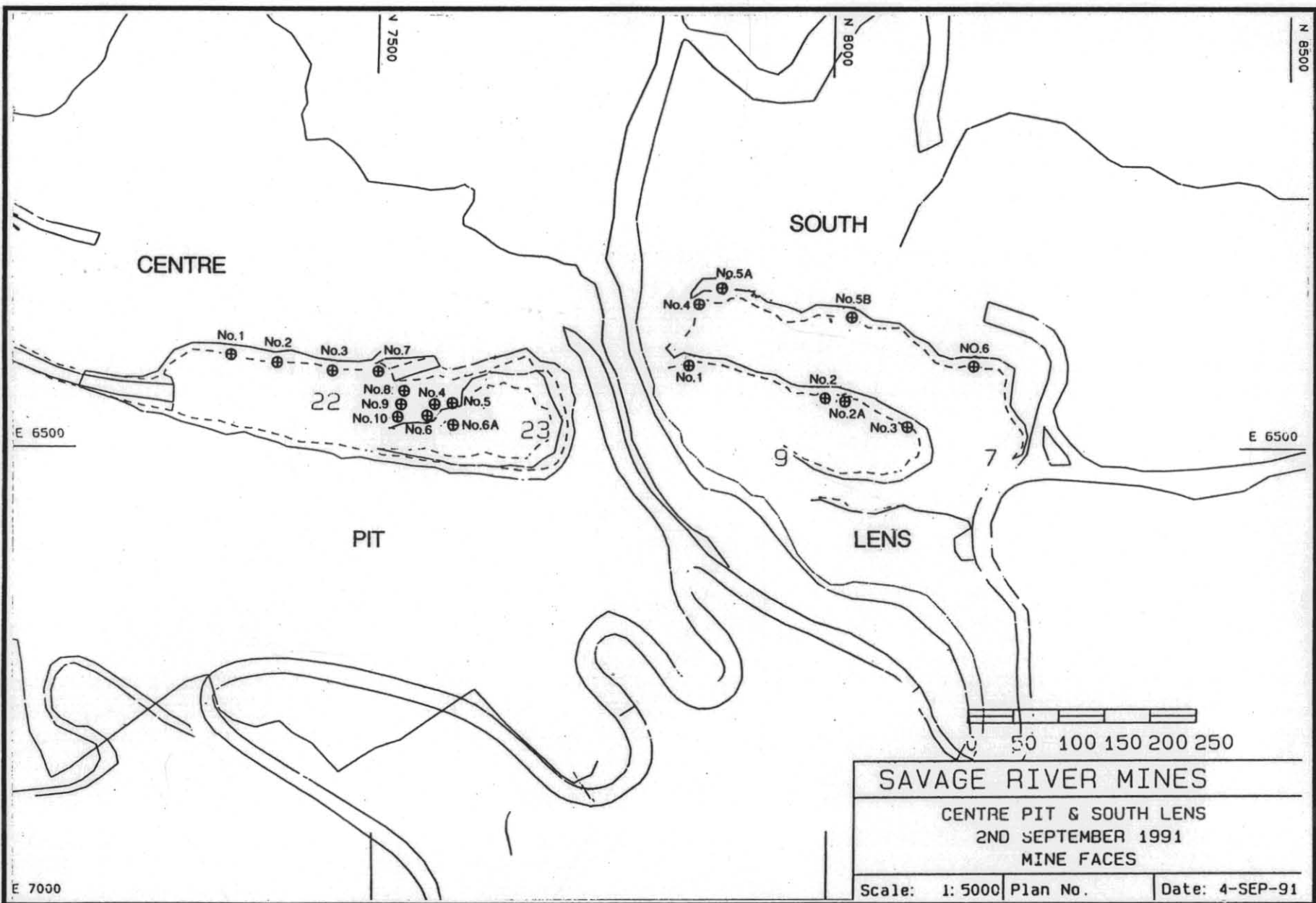
Drilling samples, Savage River Mines

Drill	NORTH DEPOSIT				SOUTH DEPOSIT				CENTRE DEPOSIT			
	Insp. Dust (mg/m ³)	Amphib.	Fibre (%)	Fibre Count (F/mL)	Insp. Dust (mg/m ³)	Amphib.	Fibre (%)	Fibre Count (F/mL)	Insp. Dust (mg/m ³)	Amphib.	Fibre (%)	Fibre Count (F/mL)
45R1	0.69	-	2									
40R1	2.03	Y	5	too high dust to count								
45R1	0.21	-	NE									
45R1	0.63	-	NE									
40R1	3.83	Y	5									
45R1	ND	ND	ND	<0.01								
45R2					4.92	Y	2					
					47.79	Y	ne					
					7.75	Y	3					
					1.23	Y	1					
					0.46	Y	<1					
					ND	ND	ND	0.03				
40R4									0.36	Y	1	
									0.80	-	1	
									1.15	Y	NE	
									0.71	Y	1	
									ND	ND	ND	0.02

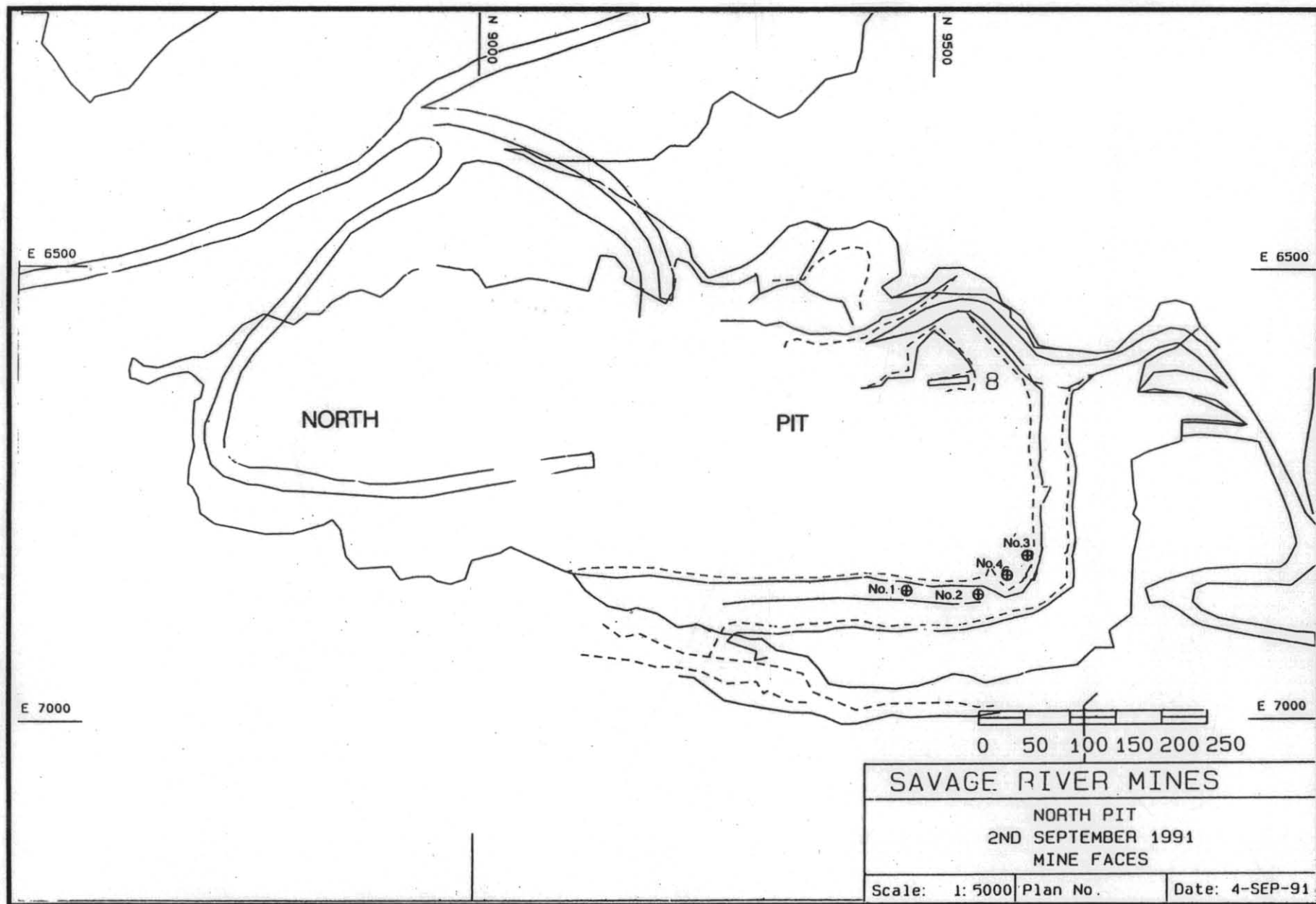
Y = amphibole present
 NE = not examined
 ND = not done

APPENDIX 7

Bulk sample locations, Savage River Mines



5 cm



5 cm

18/23

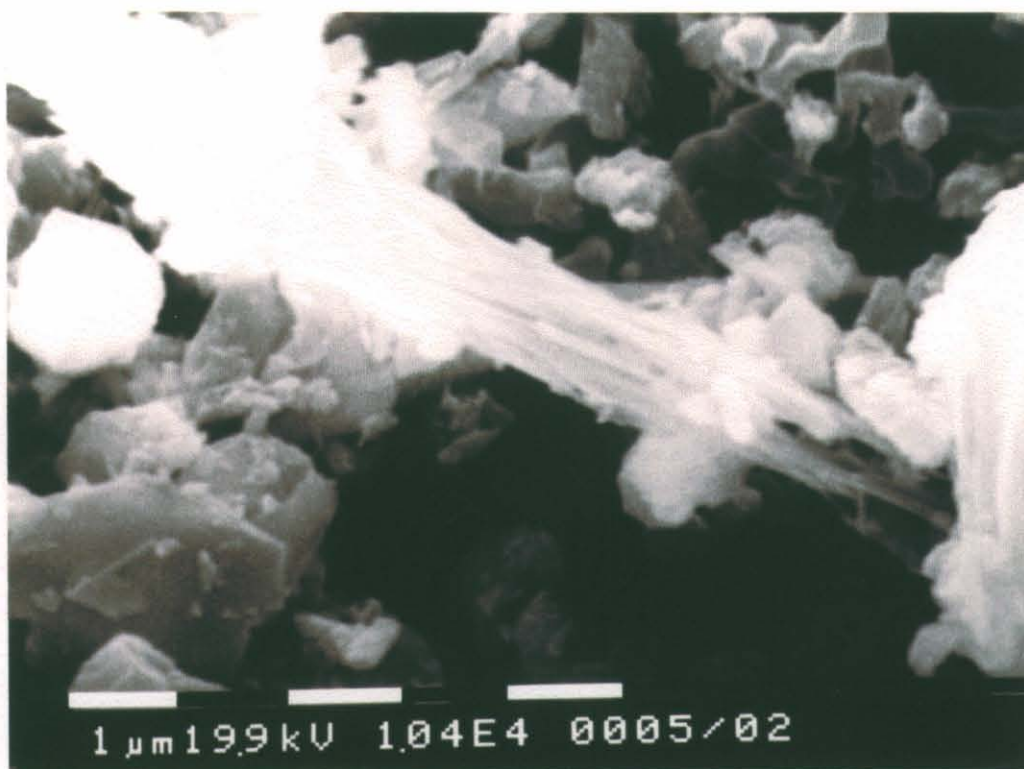
PHOTOGRAPHS



SEM photograph of asbestos fibres on a Millipore membrane filter,
Sample 19, PH 1 shovel, Centre Deposit.
Magnification: 9150x, scale bar = 10 µm.



SEM photograph of an asbestos fibre on a Millipore membrane filter,
Sample 19, PH 1 shovel, Centre Deposit.
Magnification: 5950x, scale bar = 10 µm.

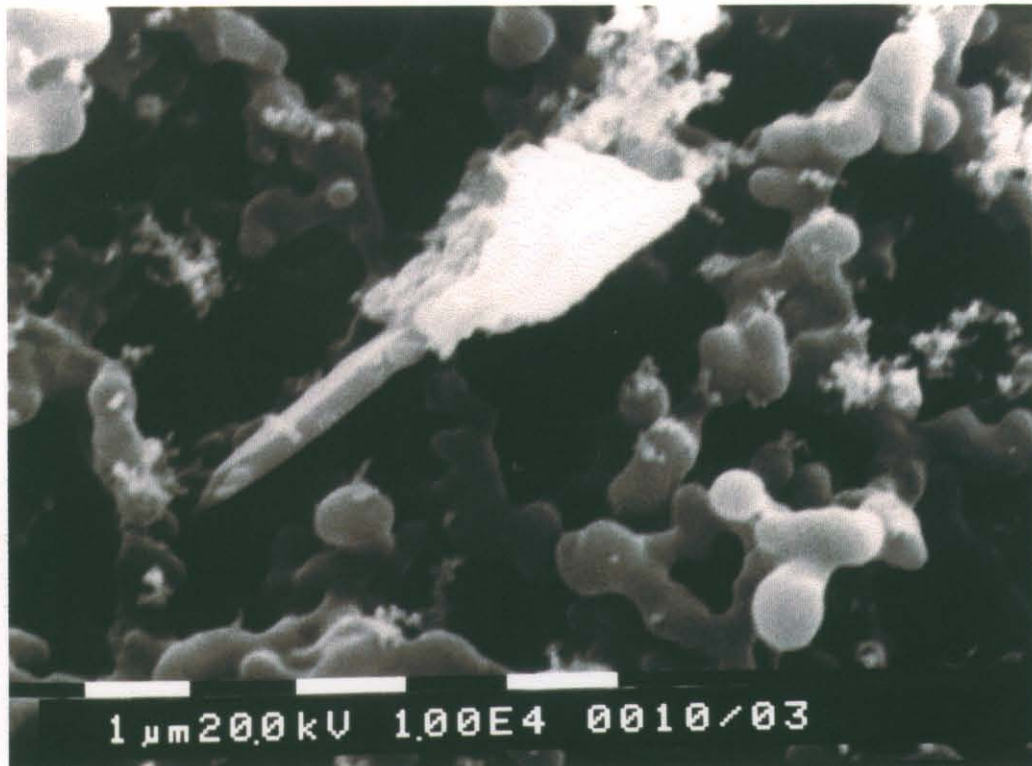


SEM photograph of asbestos fibres on a Millipore membrane filter,
Sample 107, drill 45R2, South Lens.
Magnification: 1040x, scale bar = 1 µm.

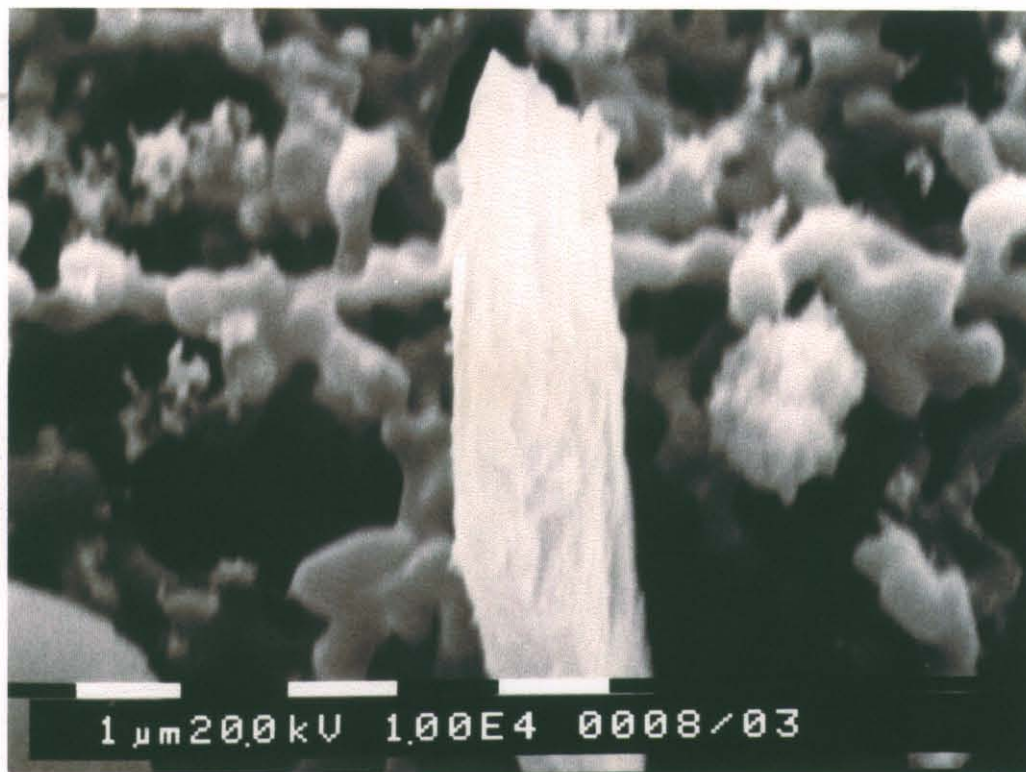


SEM photograph of an asbestos fibre on a Millipore membrane filter,
Sample 107, drill 45R2, South Lens.
Magnification: 8050x, scale bar = 10 µm.

5 cm



SEM photograph of asbestos fibres on a Millipore membrane filter, Sample 113, crusher cab. Magnification: 10 000x, scale bar = 1 µm.

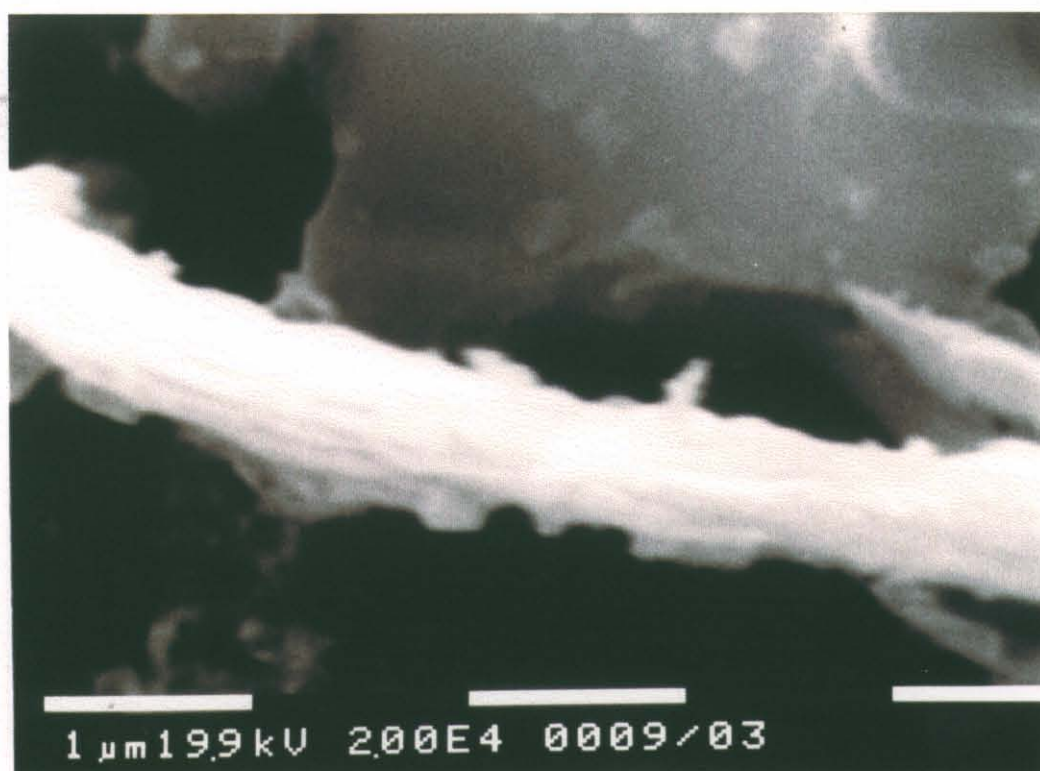


SEM photograph of an asbestos fibre on a Millipore membrane filter, Sample 113, crusher cab. Magnification: 10 000x, scale bar = 1 µm.

5 cm



SEM photograph of asbestos fibres on a Millipore membrane filter, Sample 113, crusher cab. Magnification: 10 000x, scale bar = 1 µm.

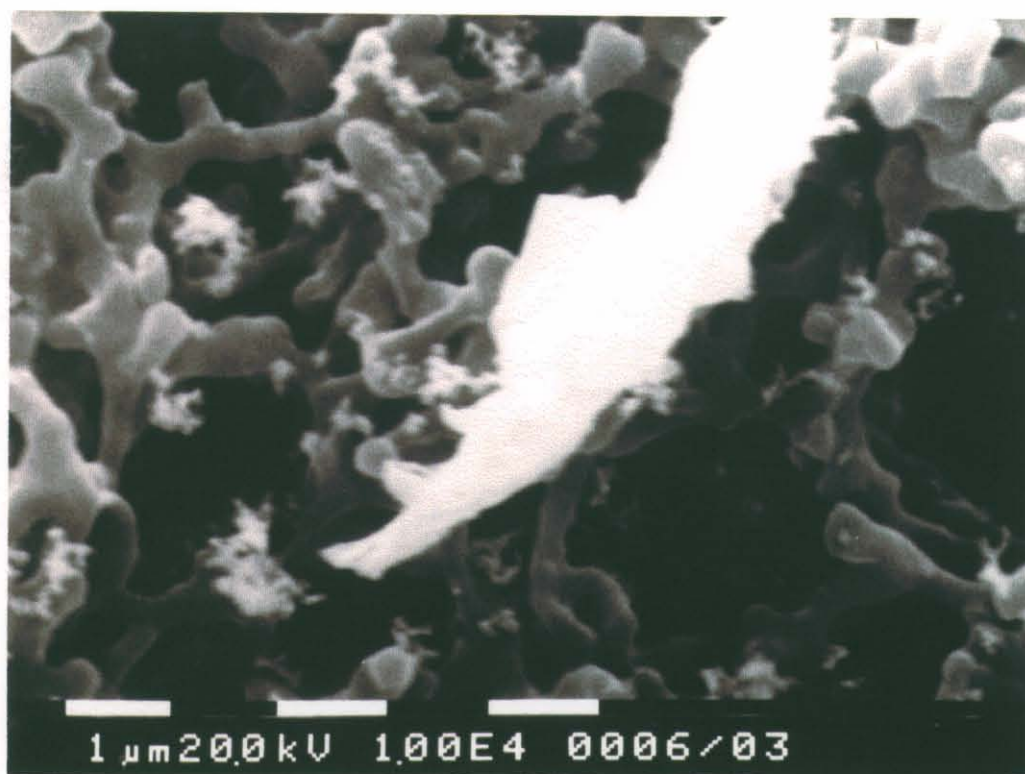


SEM photograph of an asbestos fibre on a Millipore membrane filter, Sample 113, crusher cab. Magnification: 20 000x, scale bar = 1 µm.

5 cm



SEM photograph of asbestos fibres on a Millipore membrane filter, Sample 113, crusher cab. Magnification: 10 000x, scale bar = 1 µm.



5 cm