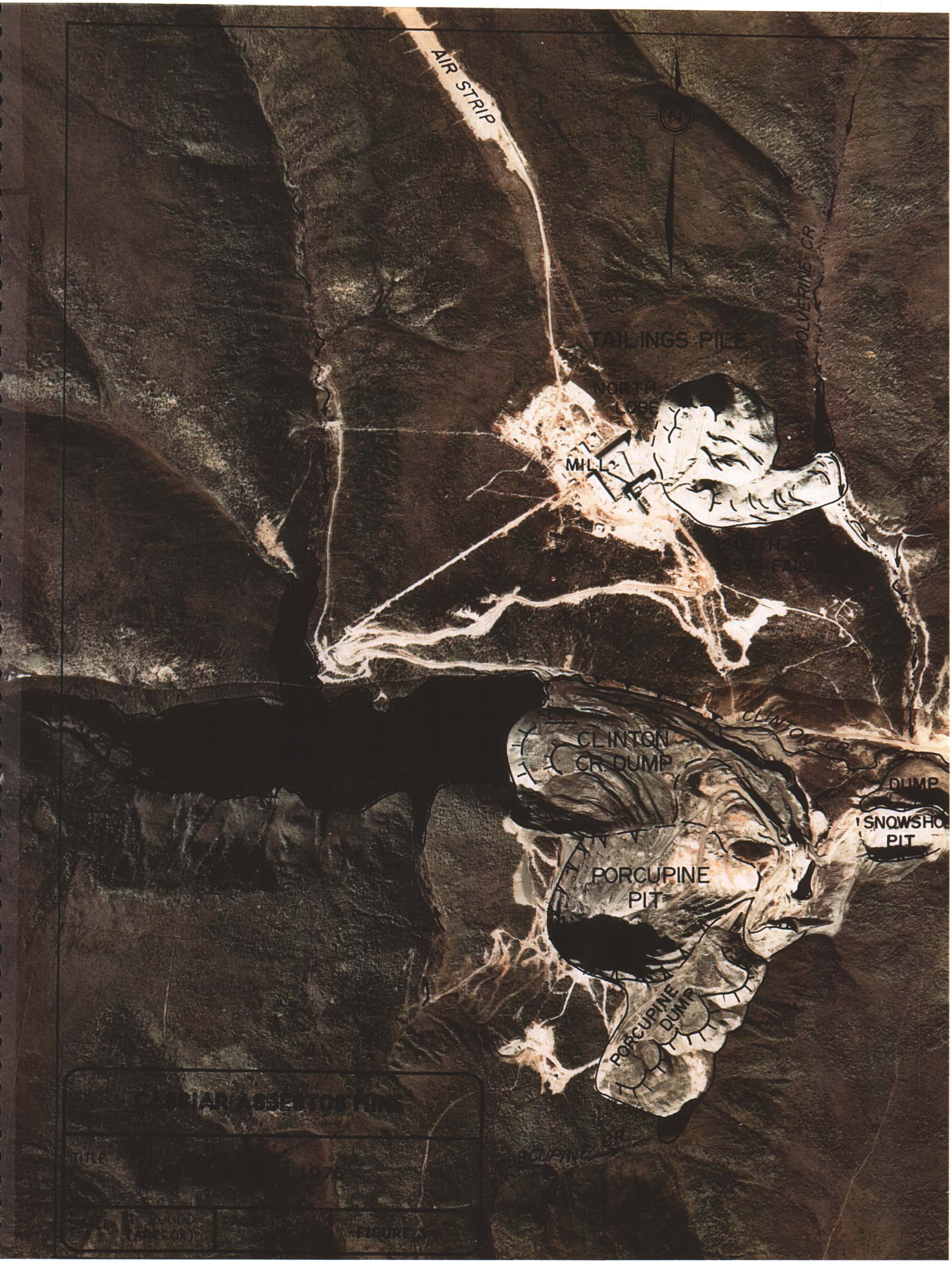
ABANDONED CLINTON CREEK ASBESTOS MINE

January 1998


AIR STRIP
TAILINGS PILE
NORTH LOBE
MILL
CLINTON CR.
CLINTON CR. DUMP
DUMP
PORCUPINE PIT
PORCUPINE DUMP
CASSIAR ASBESTOS MINE
TITLE

ABANDONED CLINTON CREEK ASBESTOS MINE

A Water Contaminants Evaluation
File 9590-2-6
by

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SUMMARY

The Clinton Creek asbestos mine was operated by the Cassiar Asbestos Corporation Limited from October 1967 until August of 1978. The mine is located 86 kilometres northwest of Dawson City, Yukon and consists of three open pits, located on the south side of Clinton Creek. The Northern Inland Waters Act came into being in 1972 and the Yukon Water Board issued a water licence in 1975. A new licence was issued in 1978. In 1983, this licence was extended to 1987. After a Water Board hearing in 1987, a Water Licence was issued which allowed the Cassiar Asbestos Corporation to abandon the Clinton Creek site. This licence was rejected by the Minister of DIAND on the basis of transferring liability for the site to the Crown. The existing licence lapsed on 30 September, 1987. An unsigned letter of agreement between the Company and DIAND was prepared in 1988, that would have allowed the Company to abandon the site after a minimum of required work. Since that time the site has continued to deteriorate.

There are 60 million tonnes of waste rock which have blocked the drainage of Clinton Creek and formed Hudgeon Lake. The mill produced one million tonnes of long fibre asbestos and discharged 10 million tonnes of tailings to the Wolverine Creek valley. The tailings dumps have since failed and formed two lobes, blocking the flow of Wolverine Creek. The creeks have eroded both the tailings piles and waste rock causing intermittent failure of impoundments and the aggradation of both creeks. The fish habitat of upper Clinton Creek and Wolverine Creek has been destroyed through physical deposition of material in the creeks.

Grab samples collected of the mine site drainage and receiving waters produced results that are ambiguous, regarding the background levels of asbestos within the affected drainage, and the impacts of erosion into Clinton Creek. All of the asbestos fibre observed is of the chrysotile variety, which is considered to be the most benign form. There are no Canadian water quality guidelines for asbestos and no clinical effect has been observed from consumption of asbestos fibre. The US EPA has set a limit of 7.0×10^6 fibres per litre for drinking water.

There are serious concerns regarding the physical stability of the site and the threat posed to public safety. Clinton Creek has incised back toward the outlet of Hudgeon Lake and there could be a rapid discharge of a large volume of water. The tailings piles continue to block Wolverine Creek. Sudden failures cause the release of large amounts of water and asbestos fibre. There are natural high water events on an irregular basis which add to the risk of sudden flood.

The risk to public safety is low as long as development within the flood plain is restricted. The town site is safe from high water events, but the access to the town site across Clinton Creek is exposed. Recent development in the town site has increased the risk of exposure,

placer mining access is compromised, and there are risks to the small amount of annual camping near the Creek

There is a physical risk to public safety if there is no long term monitoring and maintenance of the site, through the potential for sudden high flow conditions. The risks to the aquatic environment, especially fish and their habitat, are unknown at present and should be investigated. There is limited or no risk from the consumption of water with elevated asbestos levels.

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ACKNOWLEDGEMENTS

The author would like to thank M. Stepanek for providing the aerial photograph of the Clinton Creek site. Advice and historical perspective were provided by A.Von Finster and H.F. McAlpine. A number of the photographs are courtesy of H.F. McAlpine. Editing was provided by D.Sherstone.

INTRODUCTION

The Clinton Creek asbestos mine (Lat, 64° 22' 23" N Long, 140° 42' 50" W) was operated as an open pit mine by the Cassiar Asbestos Corporation Limited from October, 1967 until August of 1978. The site had been originally staked in 1957 and acquired by Cassiar later that same year. After initial sampling the site was dormant until 1964, when development of the mill and mine site commenced (1). The mill buildings and town site were disposed of at auction in 1978.

The site is in hilly and unglaciated terrain 86 kilometres northwest of Dawson City, Yukon. The mine consists of three open pits, located on the south side of Clinton Creek (Photo A). The waste rock from these pits was dumped adjacent to the pit sites with the largest volume being located to the south of Clinton Creek. There are approximately 60 million tonnes of waste rock, the movement of which blocked the drainage of Clinton Creek. The body of water formed by this blockage is referred to as Hudgeon Lake (Photo B), and the waste rock continues to creep down slope. An additional 3 million tonnes of waste rock has formed an impoundment on Porcupine Creek.

The mill was located on a flat ridge north of the mine site (Photo C). The mill produced one million tonnes of long fibre chrysotile asbestos and discharged 10 million tonnes of tailings with a conveyor stacker to the west slope of the Wolverine Creek valley (Photo D).

The tailings were stacked in two piles, which have since formed two failures known as the north and south lobes (Photo E). The original tailings pile was the south lobe which failed in 1974 and blocked the flow of Wolverine Creek, creating an unnamed lake. The north site was employed following this failure and tailings were deposited there until closure. The north lobe failed in 1976 and added to the blockage of Wolverine Creek. Since that time the creek has eroded both the tailings pile and the east bank of the valley (Photo F). This combination of erosion and blockage has caused the intermittent failure of impoundment with often dramatic results downstream on Wolverine Creek. In the spring of 1997, a large flow of water discharged past the Clinton Creek impoundment and resulted in serious erosion of the mine site road access (Photo G and H). It is likely that this is typical of the area's hydrological regime (1,2,3,4,5,6).

LICENCING

After the Northern Inland Waters Act came into being in 1972, the Yukon Water Board held a public hearing in 1975 to issue a water licence to the Cassiar Asbestos Corporation Ltd. A licence for the town site, to withdraw water from the Fortymile River and deposit treated sewage to the same (7), was issued in 1976. In 1978 a new licence was issued for the mill site with an expiry date of 1982. In 1983, this licence was extended to 1987.

PHYSICAL CONSIDERATIONS

Background

A large number of evaluations of the tailings and waste rock instability have been conducted over the years, during and after mine operations. The majority of these reports have been produced by consultants working for Cassiar Asbestos or DIAND. The evaluations have been contradictory, especially with regard to mine site abandonment by Cassiar. A number of abandonment related actions were employed, especially on the Clinton Creek channel, with an eye toward controlling erosion of the channel. This work on the Clinton Creek channel has not been successful, to date. There has been an equal amount of interest in compensating for the instability of the tailings piles and eliminating any distribution of asbestos dust. The dust has since ceased to be an issue, as a crust has formed on the tailings. No attempts made to compensate for the movement of the north and south lobes have been successful.

Waste Rock Piles

The monitoring of the Clinton Creek dump began in 1977 and the monitoring sites have since been destroyed, replaced, and destroyed again (4,8). Ground monitoring of the site appears to have ceased in 1986 and been replaced by visual evaluations of movement through photographs and terrain features (9). The movement of the waste rock piles was recorded as being between 60 and 200 cm per year in 1978 (4,7,10) and has since been estimated at 30 to 50 cm per year (8).

The effect of this movement on Clinton Creek has been to increase erosion of the bed and north bank of the Creek. Several attempts at remedial work in the creek channel have been made. Initial construction of rock weirs in the channel was done in 1979, with subsequent work to provide additional armouring for the stream banks and weirs (11). This construction failed in 1982 and was rebuilt with geo-textile fabric and more robust weir work in 1984 (4,12,13). The majority of this work has subsequently been degraded by erosion. The stability of the outlet to Hudgeon Lake was provided through removal of most of the culverts and the provision of an open channel discharge from the Lake (Photo I), with work on the site occurring as late as 1991. No work has been conducted since that date (14).

Tailings Piles

The tailings piles have been eroding into Wolverine Creek since the failure of the south lobe in 1974. The progressive failure of the north lobe, beginning in 1978 and reaching the creek in 1985, has served to block the creek and increase erosion of the east bank since that time. The channel at Wolverine Creek has received attention similar to that at Clinton Creek over the same time frame. The armouring of the creek channel with weirs was conducted in 1979 (Photo J). The weir construction has faired better than that in Clinton Creek and has remained relatively intact, although the outfall channel is unprotected and continues to erode (4,14).

The continuing movement of both lobes had, with the movement of the north lobe in 1985, produced two separate impoundments of water in the Wolverine Creek valley (14). Subsequent beaver dam construction has added to channel blockage and the storage of water in the impoundment. The north and south lobes were terraced in 1978 (Photo E) and although no successful stabilization of the 10 million tonne piles had occurred, it was assumed that they would reach a state of equilibrium by 1987 (15). Since that time the piles have continued to move in an erratic manner, with rates of as high as 19 metres per year being identified (15,16), and have produced subsequent, sudden failures as they block and burst in the valley channel (14).

The surface stability of the tailings was cause for concern at one time and a study was commissioned to investigate the potential to reduce erosion and the risk of "fugitive" dust producing airborne asbestos (17,18). By 1984, it was recognized that the crust that had formed on the surface of the tailings had reduced airborne transmission and most of the surface erosion.

ABANDONMENT

Environmental Aspects

While the large number of studies and reports on the physical aspects of the mine site, only two studies were conducted of the environmental impacts on the area (2,19). A report (2) from the Department of Environment indicated that while the site was having an effect on the water chemistry, there was no discernable impact on the aquatic ecosystem from this source, and bioassays from the site were not toxic to fish. Benthic sampling at the site produced results which proved to be representative of what could be considered normal for the area. The only concern raised was related to the effect of asbestos fibres on the gill membranes of fish. While there was no apparent long-term effect, damage to the gill tissues was demonstrated by exposing fish to Hudgeon Lake water for 16 days, but no record of asbestos fibre content of the water was supplied. The conclusions were vague on the effect of the levels of asbestos observed in the creeks. The second report (19), focused on revegetation of the area for erosion control.

After closure of the mine and prior to abandonment, other studies examined the environmental impacts related to effects on the creeks. The first (20) was an extensive evaluation of the fishery resource. It concluded that while the habitat of upper Clinton Creek and Wolverine Creek had been destroyed as fish habitat, through physical deposition of material in the creeks, the lower portion of Clinton Creek was still a valuable resource. It too, concluded that there was ambiguity regarding the effect of asbestos on the water quality. The second report (21), states that both creeks have essentially been eliminated as habitat through material deposition and that the slow or rapid failure of either waste rock or tailings features upstream will have little impact on an already damaged environment. DIAND staff collected asbestos grab sample data from the site and receiving waters, which is presented in Appendix A and summarized in Table 1. The results are not conclusive and indicate a need for further sampling.

The reports concerning fish and asbestos (2,20) did not list any asbestos concentrations for the water in question. This has made evaluating the DIAND data, in terms of the potential effect on fish habitat, impossible without further study.

Physical Concerns

The physical aspects of the site, with regard to abandonment, have received the most attention of past reports. The unstable nature of the waste rock and tailings has figured prominently in any risk evaluation for the Clinton Creek Mine property. The environmental impacts to the water quality are directly dependent on the physical deposition of material resulting from the movement of tailings and waste rock. The repeated destruction of habitat in Clinton and Wolverine creeks is tied to the input of material from the movement of waste rock and tailings down the valleys (Photo K).

An abandonment plan (21) was submitted to the Yukon Territory Water Board in September of 1986, which preceded a public hearing in January of 1987 (22). DIAND submitted an evaluation (23) of the proposed abandonment plan, which had been completed by an engineering firm under contract for that purpose.

In an extensive intervention and questioning at the public hearing (22a), the Department of Fisheries and Oceans indicated that they were very concerned about the stability of the waste rock and tailings and their potential effects on Clinton Creek and the Forty Mile River. DFO stated that the rock lined channel, claimed by the consultant for Cassiar (21) to have been stable since 1983, was visibly eroding and allowing further deposition of materials into Clinton Creek (Photo L). Fisheries then made the case for the stabilization of both tailings and waste rock, and the retention of the artificial impoundment referred to as Hudgeon Lake. The Lake was seen as a source of new fish diversity for the drainage. The current physical conditions at the Lake allows fish egress from the Lake but would prevent their return. Cassiar Asbestos suggested that as there were no baseline data for the productivity of Clinton Creek and the Forty Mile River, there was a limited case for protection of habitat.

Predominant in the concerns regarding the physical stability of the site has been public safety. The various reports have all considered the risk to life and the environment posed by the waste rock and tailings blockages of their respective creeks. The reports produced for the Cassiar Asbestos Corporation have consistently reported that the risk to life was minimal, and that as the environment was already affected, that any further impacts would be minimal (15,20). The Consultants to DIAND have assigned a higher level of risk (10,11,13,23) and referenced other historic slide failures in conditions similar to those on the site (24). A paper presented at a conference in 1992 (25) suggested that the risk to both the environment and the public was still high.

Past Recommendations

The focus of plans for the Clinton Creek site, by the Cassiar Corporation and it's consultants, was on those measures which would provide for maintenance-free abandonment (15,21,22). There were a number of physical modifications which were proposed and rejected by the consultant on the basis of cost (15). The consultant's view was that the site should be left to natural forces.

In the case of the waste rock dump, this included:

Suggested Action	Response (Cassiar's Consultant)
• lowering the level of Hudgeon Lake	none - would happen naturally
• remove the waste dump	none - too expensive
• abandon to natural developments	preferred option.

The tailings received a similar review:

	Suggested Action	Response (Cassiar's Consultant)
•	stream diversion	work not maintenance free;
•	removal of tailings	none - too expensive;
•	dam stabilization of toe (15,26)	work not maintenance free;
•	lower water levels	work not maintenance free;
•	abandon to natural developments	preferred option.

This list was expanded in another report (26) to include the diversion of Wolverine Creek either through or around the tailings and the use of a rock drain as a similar device. These options were reviewed and presented in a table with a rudimentary cost-benefit analysis in 1986 (23). This report detailed the limitations of the submitted abandonment plan, but did not offer specific solutions other than further study of the issues. The 1986 report, other earlier reports (11,26), and presentation at the public hearing in 1987 (22) suggested that it was not possible for the site to be successfully abandoned in a maintenance-free condition. The primary concern was the risk to human life, which Cassiar's consultant had calculated to be 1:25,000 (15).

After the Water Board hearing in 1987, a water licence was issued which allowed the Cassiar Asbestos Corporation to abandon the Clinton Creek site after some minor remedial work and the posting of signs warning of a flood hazard. There was also a letter of agreement between Cassiar Asbestos and a consultant to monitor the site for seven years after the expiry of the existing licence. This licence was subsequently rejected by the Minister of DIAND and returned to the Water Board for review (27). The Minister's concerns were related to the potential for leaving the Crown without the ability to insure that monitoring would take place and transferring liability for the site to the Crown. The existing licence lapsed on 30 September, 1987, prior to any resolution of the issue. On 25 April, 1988, a letter of agreement was prepared between the Company and DIAND, that required work to be conducted in the channel below Hudgeon Lake, the posting of flood warning signs, town site clean-up, cleaning of PCB contaminated transformers, crusher inactivation, the acquisition of liability insurance by Cassiar Asbestos, and an affirmation of continued liability for the site. The work progressed and the bond posted by the Company was returned in 1990.

Town Site

The town site of Clinton Creek is associated with the mine, but not directly within any abandonment reviews of the site. Later discussions between Cassiar Asbestos, DIAND, and DOE, were focussed on physical dangers from abandoned structures and the presence of PCBs in transformer oil. There were operational problems within the power complex for the town, which may have left hydrocarbon contamination of area soils and the Fortymile River gravels (28). The haul road was also a concern not directly covered in any abandonment plans. During operations, there had been numerous deposits of crushed asbestos ore, waste rock, and fibre along the haul roads within the site and the road access to Dawson City (29). Physical risk to human life at the town site was assumed to be small from any flood event and rested primarily with abandoned infrastructure within the site (Photo M). The town site is privately owned and there are plans for development of residential sites within this area (30).

Current Conditions

The deterioration of the waste rock and tailings piles has progressed as predicted (14,25). The waste rock piles have continued to move slowly and Clinton Creek has continued to cut into it's channel and incise back toward the outlet of Hudgeon Lake. The tailings piles have continued to move rapidly and periodically block Wolverine Creek, while forcing it against the opposite bank. The blockages experience sudden failures and the release of large amounts of asbestos fibre and associated material into the creek. There are occasional "natural" high water events which have produced significant erosion of materials in both creek channels and associated embankments. This deposition of material has continued the aggradation process in Clinton Creek.

The aquatic environment of Clinton Creek has continued to deteriorate through the bed loading of erodible material. Wolverine Creek was effectively defunct as a fish bearing water at abandonment and this continues to be the case. Fishery studies (31) have been carried out in the Fortymile River and adjacent creeks, including Clinton, since the Water Board hearing in 1987. This body of work has documented the use of the Fortymile River system for spawning by Chinook and Chum salmon. The associated creeks, including Clinton Creek, have been identified as habitat for juvenile salmon and other species, such as grayling. The present condition of Clinton Creek prevents fish from reaching Hudgeon Lake, but despite a lack of baseline data, the fishery work conducted in the area makes it likely that the use of the creek would have been much more extensive than at present. The increasing aggradation of Clinton Creek has made large stretches undesirable to fish, as the shallow depth leaves them vulnerable to predation.

ENVIRONMENTAL WATER QUALITY

Grab samples were collected of the mine site drainage and receivng waters. They were analysed for asbestos concentration and type. The results are presented in Table 1., from the data collected in Appendix A. Table 2 lists the results of sampling in the Yukon River watershed near Whitehorse for comparison. A consistency within both Tables, is that all of the asbestos fibre observed is of the chrysotile variety. There are two other types that occur, crocidolite and amosite. Chrysotile asbestos is considered to be the form which presents the least risk of morbidity. It is the most common form found in serpentine and, as indicated in the Tables, appears to be the only form commonly found in Yukon waters. There are no Canadian water quality guidelines for asbestos. No strong clinical connection has been made between the oral ingestion of asbestos fibre and any sort of morbidity. Asbestos absorbed in the diet is passed in faeces and urine. The US EPA has set a limit of 7.0×10^6 fibres per litre for drinking water, with the concern based on the inhalation of fibres within aerosols (32).

Table 1 lists the data obtained through grab sampling. While the samples collected in 1995 seem to follow a logical progression, there is no such continuity within the 1996 sample set. It is tempting to suggest that the two samples collected at Wolverine Creek, below the tailings, represent the possible high and low levels of asbestos fibre for the Creek. Alternately, it could be suggested that the levels for the 1996 Wolverine Creek sample and the one for the Yukon River below the Fortymile River have become mixed in the lab. The value for the Fortymile River below Clinton Creek appears suspect when compared to the values upstream and at the Clinton Creek ford. It is possible that problems at the lab that generated such mixed results, but they are equally explainable as the variability inherent in grab sampling. The value for Hudgeon Lake could be at the same level which caused the gill damage to the fish immersed in it for 16 days in the 1978 DOE study (2), but the original levels were never recorded.

CONCLUSIONS

The progressive deterioration of the Clinton Creek site has proceeded much as was predicted in the various reports. If the Clinton Creek site remains abandoned without further work on the site, it appears inevitable that Clinton Creek will continue to erode the bed of it's channel, until the integrity of Hudgeon Lake is compromised. The result of this could be a lowering of the Hudgeon Lake level to that of the downstream weir, a change in elevation of from three to five metres (5). The Lake will not drain completely, however the loss of water could generate significant short-term flows.

The continuing movement of waste rock into the creek channel will contribute to the aggradation of Clinton Creek. Wolverine Creek will continue to be blocked and could experience failures of these impoundments, with the subsequent deposit of bed load materials to Clinton Creek and the Fortymile River as receiving waters. The loss of fish habitat in both creeks is likely to persist.

The levels of asbestos in the Fortymile River downstream of Clinton Creek, and the Yukon River downstream of the Fortymile, are certainly influenced to some degree by what is discharged from Clinton Creek. The results from Table 1 are ambiguous and offer only a suggestion of the possible loading to each water source. There is certainly asbestos in both the Yukon River and the Fortymile River upstream of Clinton Creek. What influence the small average flow of Clinton Creek has on these larger systems is uncertain. A slug flow scenario is probable with either a breaking impoundment or a high water event as the source. A failure of an impoundment would likely have the greater ability to influence water quality in the Fortymile, as a high water event would be common to both. The effect of any increase in asbestos levels are also open to discussion. There is certainly a level at which asbestos can be injurious to the gill membranes of fish. Unfortunately there is no conclusive data available on this subject and no guideline or standard, beyond a single EPA value for drinking water.

Natural high water events will contribute to erosion and provide a risk to human life in the downstream channel. This risk is low as long as development within the Clinton and Wolverine Creek channels is restricted. The town site is sufficiently removed from the channel to be safe from high water events, but the access across Clinton Creek into this area is exposed to flood events (Photo N). Recent development in the town site increases the risk through an increase in traffic at the crossing. As this is also the access to the Fortymile placer region, any increase in activity in this area will have similar subsequent increases in exposure of the public to flood events. The area also experiences a limited amount of recreational camping near the Creek (Photo O) at a site which could be affected If there is no long term monitoring and maintenance of the site, the rate of erosion and potential for sudden high flow conditions, and the accompanying risk, is of concern.

TABLE 1. ASBESTOS CONCENTRATIONS IN WATER AT CLINTON CREEK

Sample Date	Location	Total Asbestos Concentration (fibres per litre)	Chrysotile Asbestos Concentration
July 1996	Wolverine Creek below tailings	1.67×10^5	1.67×10^5
July 1996	Yukon River below Fortymile River	33.51×10^6	33.51×10^6
July 1996	Fortymile River above Clinton Creek	7.18×10^5	7.18×10^5
July 1996	Fortymile River below Clinton Creek	0	0
July 1996	Clinton Creek at Town site ford	1.20×10^6	1.2×10^6
August 1995	Hudgeon Lake	1.98×10^5	1.98×10^5
August 1995	Clinton Creek at Bridge	54.72×10^6	$54.72\ 10^6$
August 1995	Open Pit	74.43×10^6	74.43×10^6
August 1995	Wolverine Creek below tailings	1.74×10^9	1.74×10^9
August 1995	Clinton Creek at confluence with Wolverine Creek	142.9×10^9	142.9×10^9

TABLE 2. ASBESTOS CONCENTRATION IN THE WHITEHORSE WATERSHED

Sample Date	Location	Total Asbestos Concentration (fibres per litre)	Chrysotile Asbestos Concentration
July 1996	Whitehorse tap water	6.37×10^5	6.37×10^5
August 1997	Nares Lake upstream of 10 Mile Point	0	0
August 1997	Windy Arm upstream of Bove Island	33.50×10^3	33.50×10^3
August 1997	Taku Arm at Tagish Lake	0	0
August 1997	Tagish River upstream of Tagish	0	0
August 1997	Tagish River downstream of Tagish	0	0
August 1997	M'Clintock River at Alaska Highway	9.24×10^5	9.24×10^5
August 1997	Lewes River at Alaska Highway	0	0
August 1997	Wolf Creek at Yukon River	13.41×10^6	13.41×10^6
August 1997	Yukon River at Schwatka Reservoir	1.34×10^5	1.34×10^5

Photo A: Clinton Creek Mine Open Pits

Photo B: View of Mine with waste rock forming Hudgeon Lake

Photo C: Abandoned mill site

Photo D: Tailings on west bank of Wolverine Creek with mill site at top

Photo E: North and South lobes of tailings with North lobe at bottom

Photo F: Eroding toe of tailings and east bank of Wolverine Creek

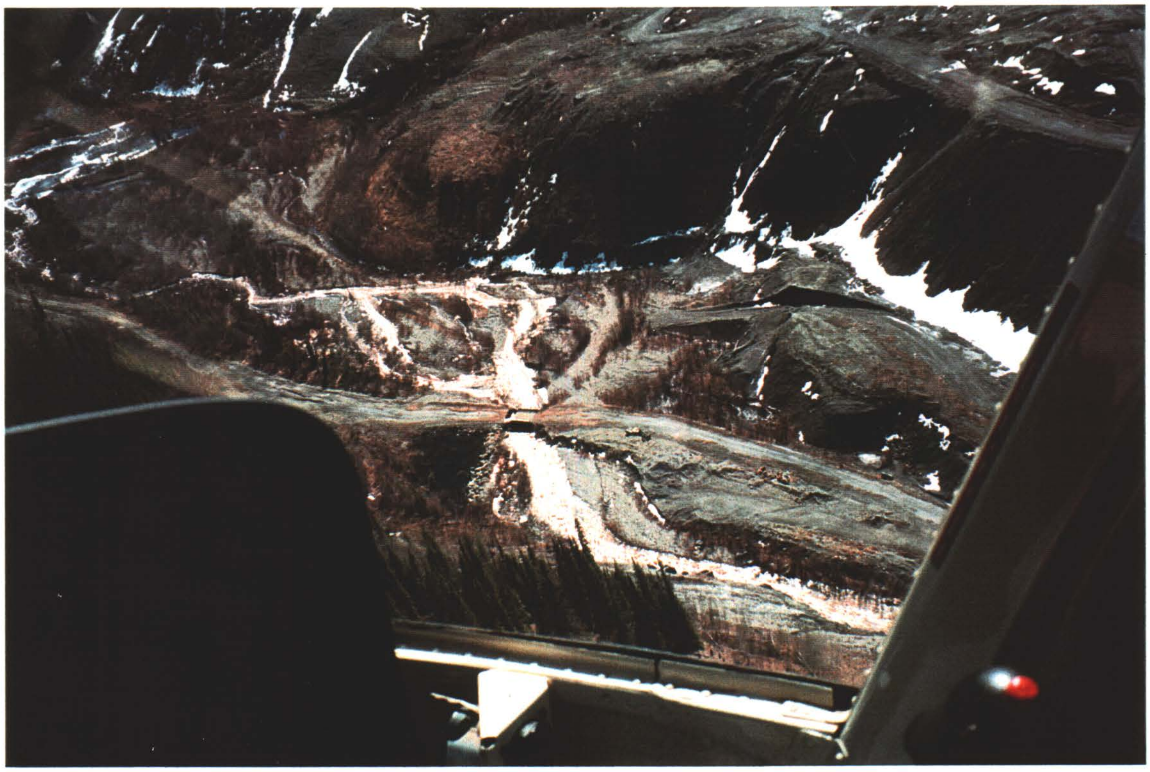

Photo G: Mine road and Clinton Creek (May 1997) - note bridge

Photo H: Mine road and Clinton Creek (June 1997) - note bridge

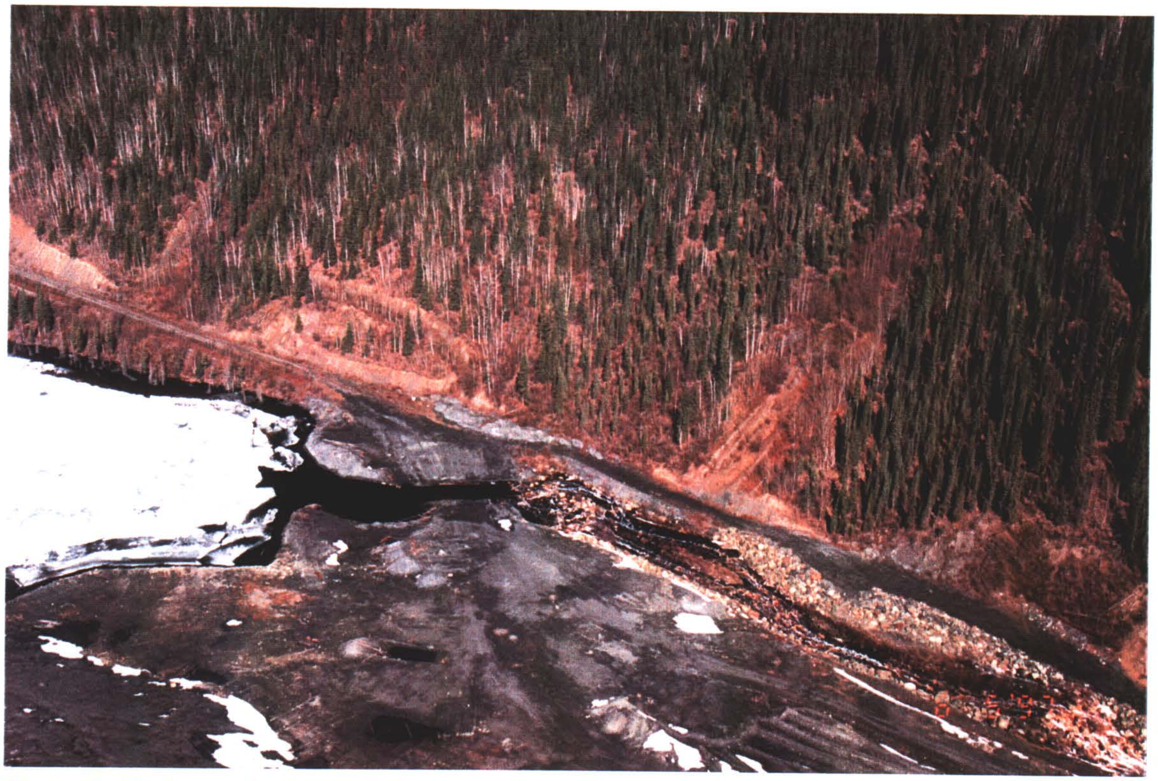

Photo I: Hudgeon Lake outfall - note channel, armouring, and weir at bottom right

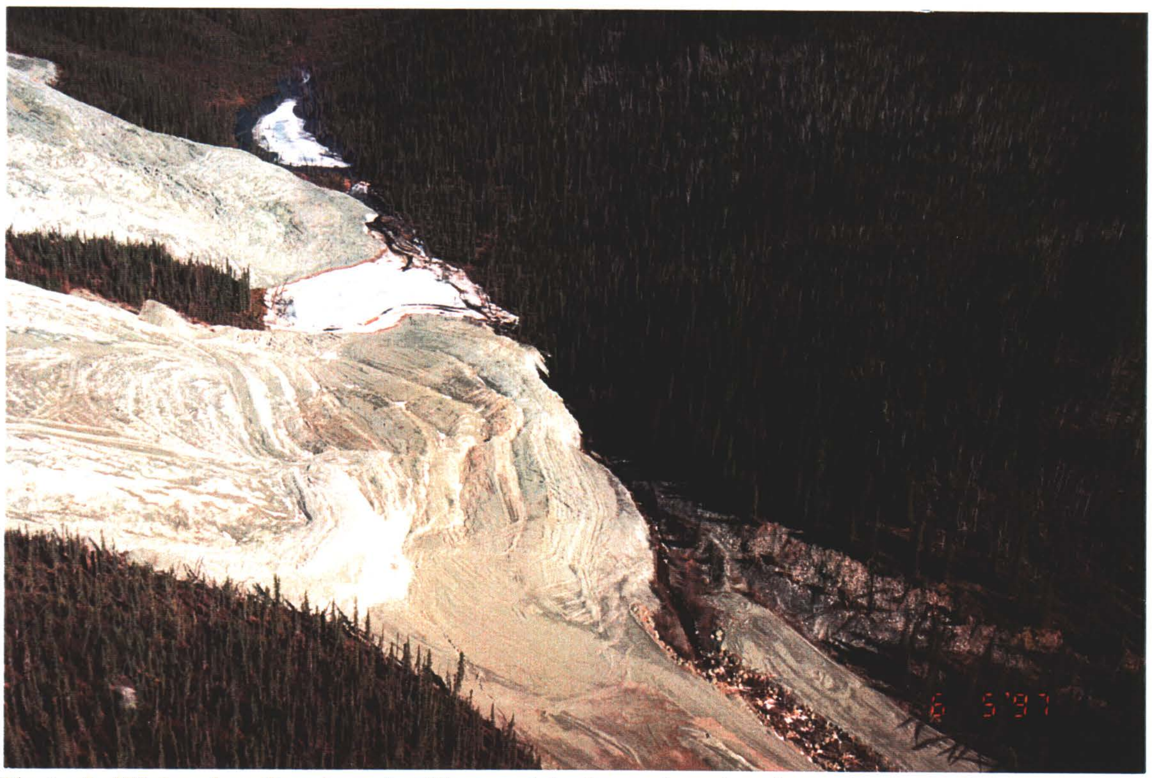

Photo J: Wolverine Creek and tailings with channel and weirs at bottom right

Photo K: Mouth of Wolverine Creek at Clinton Creek

Photo L: Clinton Creek channel - note bridge at left and change to aggrading channel

Photo M: Clinton Creek - note power plant site at centre and creek at far right

Photo N: Clinton Creek - ford crossing to town site and old bridge

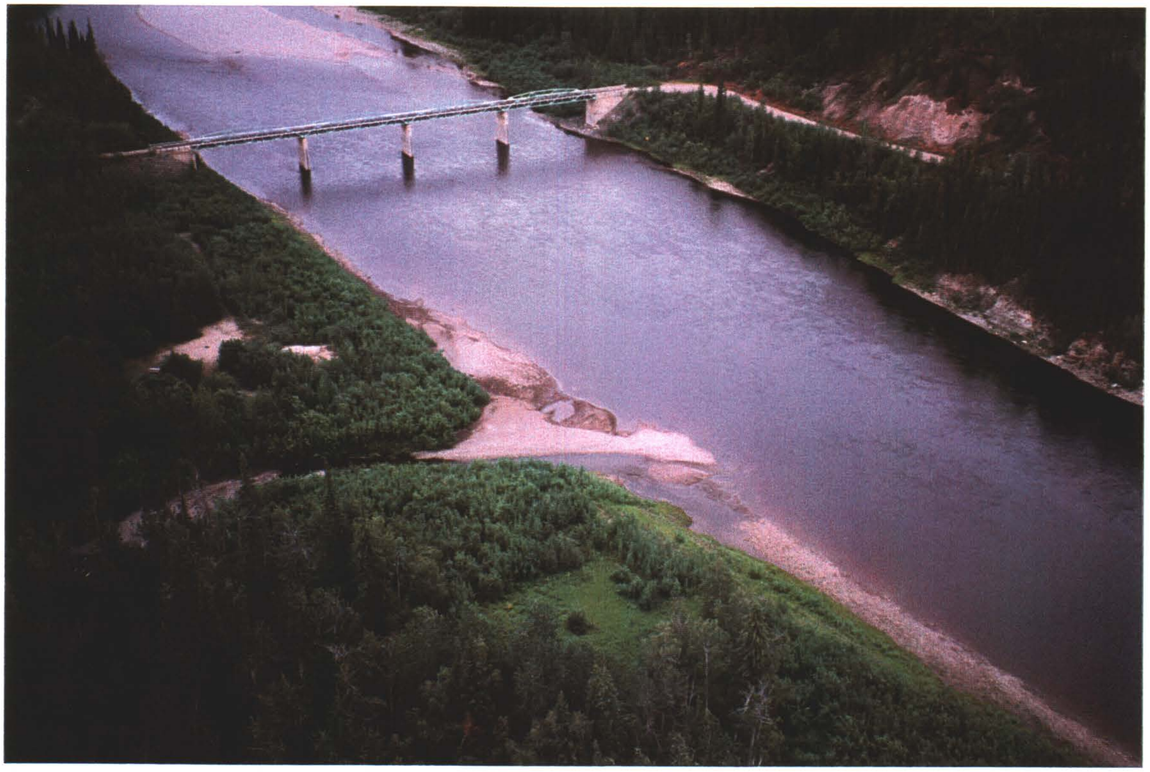

Photo O: Mouth of Clinton Creek at centre with camping area above left

Abandoned Clinton Creek Asbestos Mine 20

APPENDIX A

McMaster University

Occupational and Environmental Health Laboratory

1200 Main Street West, HSC 3H58
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September 13, 1996

Mr. Patrick Roach
Indian and Northern Affairs Canada
Water Resources Division
Northern Affairs Program
345 - 300 Main Street, Room 310
Whitehorse, Yukon Territory
Y1A 2B5

Dear Mr. Roach:

I enclose the laboratory report for the samples you submitted for analysis.

The samples were received in the laboratory on July 29, 1996. They consisted of six water samples for analytical transmission electron micrscope (ATEM) asbestos fibre analysis.

Each sample is reported individually because of the wide range of fibre concentrations found. Fibre concentrations of all fibres, asbestos fibres and asbestos type (chrysotile) are reported for all lengths and lengths greater than 5 micrometers in the first table.

A size distribution of the asbestos fibres analysed is the second table for each sample, when asbestos was found. An asbestos mass calculation expressed as micrograms (μg) per litre is given and finally, a listing of the asbestos types found, their length, diameter, aspect ratio and mass are presented.

Appendix I presents the details of the analysis. Appendix II are micrographs of some of the fibres analysed in these samples.

Please note that any unused portions of the samples which are feasible to preserve will be kept for a period of 30 days from the date on this report and then discarded, unless you have requested otherwise.

If you require any additional information, please feel free to contact the laboratory. Thank you for the opportunity to provide you with our services.

Yours sincerely,

Dave K. Verma, Ph.D., P.Eng., CIH, ROH
Laboratory Director
DKV/lmb
Enclosure
C:\61\REPORT\WATER.1

Laboratory Sample Number: 96070755 *Your Sample Identification: Wolverine Creek*						
Fibre Concentration (fibres per millilitre)						
All Lengths			*Length > 5 μm*			*Detection Limit*
All Fibres	*All Asbestos*	*Chrysotile Asbestos*	*All Fibres*	*All Asbestos*	*Chrysotile Asbestos*	
234.31	167.36	167.36	66.95	33.47	33.47	33.47

Asbestos Fibre Size Distribution *(expressed as a percent of the total)* *Number of Fibres Sized = 5*			
Diameter (μm)	*Length (μm)*		
	L > 5	*5 ≤ L < 8*	*L ≥ 8*
D < 0.5	80	20	nd
0.5 ≤ D < 3	nd	nd	nd
D ≥ 3	nd	nd	nd

nd - none detected

Asbestos Mass Calculation - 0.020 μg per litre					
Rec #	*Type**	*Length (μm)*	*Width (μm)*	*Aspect Ratio*	*Mass (pg)*
1	1	5.12	0.22	22.83	0.5063
2	1	2.99	0.07	40.00	0.0329
3	1	1.20	0.11	10.67	0.0296
4	1	1.23	0.06	22.00	0.0076
7	1	1.05	0.06	18.67	0.0065

* type 1 = chrysotile asbestos

Total mass (pg) = 0.5828
Number of fibres = 5

Laboratory Sample Number: 96070756 Your Sample Identification: Yukon River ~~above~~ BELOW 40 mile						
Fibre Concentration (fibres per millilitre)						
All Lengths			*Length > 5 μm*			*Detection Limit*
All Fibres	*All Asbestos*	*Chrysotile Asbestos*	*All Fibres*	*All Asbestos*	*Chrysotile Asbestos*	
160858.15	33512.12	33512.12	6702.42	<6702.42	<6702.42	6702.42

Asbestos Fibre Size Distribution (expressed as a percent of the total) Number of Fibres Sized = 5			
Diameter (μm)	*Length (μm)*		
	L > 5	*5 ≤ L < 8*	*L ≥ 8*
D < 0.5	100	nd	nd
0.5 ≤ D < 3	nd	nd	nd
D ≥ 3	nd	nd	nd

nd - none detected

Asbestos Mass Calculation - 1.00 μg per litre					
Rec #	*Type**	*Length (μm)*	*Width (μm)*	*Aspect Ratio*	*Mass (pg)*
5	1	0.87	0.08	11.50	0.0097
6	1	1.17	0.08	15.50	0.0131
14	1	2.53	0.11	22.33	0.0638
21	1	0.83	0.08	11.00	0.0093
22	1	4.72	0.08	62.50	0.0529

*type 1 = chrysotile asbestos

Total mass (pg) = 0.1489
Number of fibres = 5

Laboratory Sample Number: 96070757 Your Sample Identification: 40 mile above Clinton Creek						
Fibre Concentration (fibres per millilitre)						
All Lengths			*Length > 5 µm*			*Detection Limit*
All Fibres	*All Asbestos*	*Chrysotile Asbestos*	*All Fibres*	*All Asbestos*	*Chrysotile Asbestos*	
4021.78	718.17	718.17	1292.71	143.64	143.64	47.88

Asbestos Fibre Size Distribution (expressed as a percent of the total) Number of Fibres Sized = 15			
Diameter (µm)	*Length (µm)*		
	L > 5	*5 ≤ L < 8*	*L ≥ 8*
D < 0.5	80	7	13
0.5 ≤ D < 3	nd	nd	nd
D ≥ 3	nd	nd	nd

nd - none detected

Asbestos Mass Calculation - 0.091 µg per litre					
Rec #	*Type**	*Length (µm)*	*Width (µm)*	*Aspect Ratio*	*Mass (pg)*
1	1	2.47	0.04	66.00	0.0068
2	1	8.60	0.07	115.00	0.0944
3	1	1.12	0.07	15.00	0.123
4	1	1.57	0.19	8.40	0.1078
6	1	3.85	0.11	34.33	0.0952
8	1	2.54	0.37	6.80	0.6981
10	1	2.51	0.04	67.00	0.0069
20	1	5.61	0.07	75.00	0.0616

Asbestos Mass Calculation - 0.091 μg per litre					
Rec #	*Type**	*Length (μm)*	*Width (μm)*	*Aspect Ratio*	*Mass (pg)*
26	1	2.24	0.07	30.00	0.0246
27	1	12.98	0.13	99.14	0.4364
36	1	2.39	0.11	21.33	0.0591
43	1	2.24	0.19	12.00	0.1540
51	1	3.55	0.07	47.50	0.0390
80	1	2.99	0.07	40.00	0.0329
81	1	2.32	0.13	17.71	0.0780

*type 1 = chrysotile asbestos

Total mass (pg) = 1.9070
Number of fibres = 15

Laboratory Sample Number: 96070758 *Your Sample Identification: 40 mile below Clinton Creek*						
Fibre Concentration (fibres per millilitre)						
All Lengths			*Length > 5 μm*			*Detection Limit*
All Fibres	*All Asbestos*	*Chrysotile Asbestos*	*All Fibres*	*All Asbestos*	*Chrysotile Asbestos*	
4362.96	<41.95	<41.95	1300.50	<41.95	<41.95	41.95

Laboratory Sample Number: 96070759 Your Sample Identification: Clinton Creek Townsite						
Fibre Concentration (fibres per millilitre)						
All Lengths			*Length > 5 μm*			*Detection Limit*
All Fibres	*All Asbestos*	*Chrysotile Asbestos*	*All Fibres*	*All Asbestos*	*Chrysotile Asbestos*	
3013.56	1205.42	1205.42	669.68	133.94	133.94	66.97

Asbestos Fibre Size Distribution (expressed as a percent of the total) Number of Fibres Sized = 18			
Diameter (μm)	*Length (μm)*		
	L > 5	*5 ≤ L < 8*	*L ≥ 8*
D < 0.5	89	11	nd
0.5 ≤ D < 3	nd	nd	nd
D ≥ 3	nd	nd	nd

nd - none detected

Asbestos Mass Calculation - 0.075 μg per litre					
Rec #	*Type**	*Length (μm)*	*Width (μm)*	*Aspect Ratio*	*Mass (pg)*
2	1	2.62	0.06	46.67	0.0162
3	1	3.44	0.04	92.00	0.0094
4	1	0.75	0.06	13.33	0.0046
6	1	1.94	0.06	34.67	0.0120
8	1	2.62	0.06	46.67	0.0162
9	1	0.52	0.06	9.33	0.0032
10	1	3.59	0.06	64.00	0.0222
11	1	1.94	0.06	34.67	0.0120

Asbestos Mass Calculation - 0.075 μg per litre					
Rec #	*Type**	*Length (μm)*	*Width (μm)*	*Aspect Ratio*	*Mass (pg)*
12	1	3.59	0.06	64.00	0.0222
13	1	2.99	0.32	9.41	0.5934
17	1	5.98	0.06	106.67	0.0370
18	1	6.62	0.07	88.50	0.0727
20	1	1.16	0.07	15.50	0.0127
30	1	1.12	0.07	15.00	0.0123
35	1	4.11	0.07	55.00	0.0452
37	1	1.46	0.07	19.50	0.0160
40	1	2.43	0.19	13.00	0.1668
44	1	4.79	0.07	64.00	0.0526

*type 1 = chrysotile asbestos

Total mass (pg) = 1.1266
Number of fibres = 18

Method: Analytical Transmission Electron Microscopy, Occupational Health Laboratory Method Number 014 (see Appendix I)

Detection Limit: One confirmed asbestos fibre above the blank mean. See the fibre concentration tables for individual detection limits.

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October 23, 1995

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The samples were received in the laboratory on September 18, 1995. They consisted of five water samples for analytical transmission electron microscope (ATEM) asbestos fibre analysis.

Each sample is reported individually because of the wide range of fibre concentrations found. Fibre concentrations of all fibres, asbestos fibres and asbestos type (chrysotile) are reported for all lengths and lengths greater than 5 micrometers and are reported in the first table.

A size distribution of the asbestos fibres analyzed is the second table for each sample. An asbestos mass calculation expressed as micrograms (μg) per litre is given and finally, a listing of the asbestos types found, their length, diameter, aspect ratio and mass are presented.

The results for each water sample follow.

Laboratory Sample Number: 95090282
Your Sample identification: Hudgeon Lake

Fibre Concentration (fibres per millilitre)						
All Lengths			Length > 5 μm			Detection Limit
All Fibres	All Asbestos	Chrysotile Asbestos	All Fibres	All Asbestos	Chrysotile Asbestos	
659.09	197.73	197.73	<32.95	<32.95	<32.95	32.95

Asbestos Fibre Size distributions (expressed as a percent of the total)
Number of Fibres Sized = 6

Diameter (μm)	Length (μm)		
	L < 5	5 ≤ L < 8	L ≥ 8
D < 0.5	100	nd	nd
0.5 ≤ D < 3	nd	nd	nd
D ≥ 3	nd	nd	nd

nd - none detected

Asbestos Mass Calculation - 0.02 μg per litre of water

Rec#	Type*	Length (μm)	Width (μm)	Aspect Ratio	Mass (pg)
3	1	2.11	0.11	18.67	0.0531
4	1	1.21	0.08	16.00	0.0135
6	1	1.62	0.08	21.50	0.0181
12	1	1.89	0.04	50.00	0.0053
13	1	1.62	0.04	43.00	0.0045
16	1	3.21	0.26	12.14	0.4390

* type 1 = chrysotile asbestos

Total mass (pg) = 0.5335
Number of fibres = 6

Laboratory Sample Number: 95090283
Your Sample identification: Clinton Creek at Bridge

Fibre Concentration (fibres per millilitre)						
All Lengths			Length > 5 μm			Detection Limit
All Fibres	All Asbestos	Chrysotile Asbestos	All Fibres	All Asbestos	Chrysotile Asbestos	
58019.59	54723.02	54723.02	10549.02	9889.70	9889.70	659.31

Asbestos Fibre Size distributions (expressed as a percent of the total)
Number of Fibres Sized = 83

Diameter (μm)	Length (μm)		
	L < 5	5 ≤ L < 8	L ≥ 8
D < 0.5	82.0	6.1	12.1
0.5 ≤ D < 3	nd	nd	nd
D ≥ 3	nd	nd	nd

nd - none detected

Asbestos Mass Calculation - 4.27 μg per litre of water

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
1	1	1.70	0.08	22.50	0.0190
2	1	0.87	0.04	23.00	0.0024
5	1	1.02	0.06	18.00	0.0064
6	1	2.68	0.08	35.50	0.0299
7	1	1.55	0.04	41.00	0.0043
8	1	2.87	0.04	76.00	0.0080
9	1	1.17	0.08	15.50	0.0131
10	1	1.92	0.08	25.50	0.0215
11	1	2.04	0.09	21.60	0.0356
12	1	1.43	0.08	19.00	0.0160
13	1	12.83	0.04	340.00	0.0358
14	1	0.94	0.06	16.67	0.0059
15	1	2.83	0.08	37.50	0.0316
16	1	9.43	0.09	100.00	0.1647
17	1	4.15	0.08	55.00	0.0464
18	1	2.72	0.04	72.00	0.0076

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
19	1	1.62	0.11	14.33	0.0408
20	1	14.75	0.06	260.67	0.0927
21	1	7.54	0.04	200.00	0.0211
22	1	2.04	0.04	54.00	0.0057
23	1	2.00	0.11	17.67	0.0503
24	1	1.36	0.06	24.00	0.0085
25	1	3.40	0.08	45.00	0.0379
26	1	22.07	0.09	234.00	0.3854
27	1	1.02	0.08	13.50	0.0114
28	1	4.19	0.06	74.00	0.0263
29	1	3.40	0.04	90.00	0.0095
30	1	2.07	0.08	27.50	0.0232
31	1	1.92	0.04	51.00	0.0054
32	1	9.43	0.08	125.00	0.1054
33	1	1.17	0.08	15.50	0.0131
34	1	0.57	0.08	7.50	0.0063
35	1	4.38	0.19	23.20	0.3057
36	1	1.36	0.08	18.00	0.0152
37	1	4.19	0.08	55.50	0.0468
38	1	3.17	0.04	84.00	0.0089
39	1	1.47	0.06	26.00	0.0092
40	1	3.13	0.11	27.67	0.0787
41	1	1.24	0.02	66.00	0.0009
42	1	2.11	0.08	28.00	0.0236
43	1	0.79	0.08	10.50	0.0089
44	1	2.64	0.11	23.33	0.0664
45	1	0.98	0.08	13.00	0.0110
46	1	0.98	0.08	13.00	0.0110
47	1	3.96	0.19	21.00	0.2767
48	1	1.32	0.08	17.50	0.0148
49	1	3.96	0.04	105.00	0.0111
50	1	1.28	0.06	22.67	0.0081
51	1	3.06	0.06	54.00	0.0192
52	1	1.32	0.13	10.00	0.0452
53	1	0.87	0.04	23.00	0.0024
55	1	5.51	0.04	146.00	0.0154
56	1	3.62	0.08	48.00	0.0405
57	1	4.53	0.06	80.00	0.0285
58	1	1.62	0.08	21.50	0.0181
59	1	3.55	0.04	94.00	0.0099
60	1	2.34	0.11	20.67	0.0588
61	1	2.34	0.04	62.00	0.0065
62	1	4.79	0.08	63.50	0.0535
63	1	1.13	0.08	15.00	0.0126
64	1	2.45	0.19	13.00	0.1713
65	1	1.96	0.04	52.00	0.0055
66	1	0.87	0.08	11.50	0.0097
67	1	11.13	0.09	118.00	0.1943
68	1	8.53	0.04	226.00	0.0238
69	1	1.85	0.11	16.33	0.0465
71	1	5.02	0.08	66.50	0.0561
72	1	7.17	0.38	19.00	2.0026

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
73	1	0.94	0.08	12.50	0.0105
74	1	1.32	0.08	17.50	0.0148
75	1	2.83	0.08	37.50	0.0316
76	1	1.24	0.08	16.50	0.0139
77	1	3.89	0.08	51.50	0.0434
78	1	17.35	0.08	230.00	0.1939
79	1	2.45	0.08	32.50	0.0274
80	1	2.30	0.08	30.50	0.0257
81	1	2.87	0.11	25.33	0.0721
82	1	3.77	0.06	66.67	0.0237
83	1	4.34	0.04	115.00	0.0121
84	1	6.49	0.08	86.00	0.0725
86	1	15.09	0.15	100.00	0.6746
87	1	8.68	0.11	76.67	0.2182
88	1	2.00	0.09	21.20	0.0349

* type 1 = chrysotile asbestos

Total mass (pg) = 6.4779
Number of fibres = 83

Laboratory Sample Number: 95090284
Your Sample identification: Clinton Creek Main Pit

Fibre Concentration (fibres per millilitre)						
All Lengths			Length > 5 μm			Detection Limit
All Fibres	All Asbestos	Chrysotile Asbestos	All Fibres	All Asbestos	Chrysotile Asbestos	
79697.53	74428.27	74428.27	5269.26	5269.26	5269.26	658.66

Asbestos Fibre Size distributions (expressed as a percent of the total)
Number of Fibres Sized = 113

Diameter (μm)	Length (μm)		
	L < 5	5 ≤ L < 8	L ≥ 8
D < 0.5	93.0	5.4	1.8
0.5 ≤ D < 3	nd	nd	nd
D ≥ 3	nd	nd	nd

nd - none detected

Asbestos Mass Calculation - 2.39 μg per litre of water

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
1	1	3.62	0.08	48.00	0.0405
2	1	2.79	0.09	29.60	0.0487
3	1	1.70	0.06	30.00	0.0107
4	1	0.98	0.08	13.00	0.0110
5	1	1.24	0.11	11.00	0.0313
6	1	1.32	0.06	23.33	0.0083
7	1	1.40	0.08	18.50	0.0156
8	1	0.98	0.08	13.00	0.0110
9	1	0.75	0.11	6.67	0.0190
10	1	1.92	0.08	25.50	0.0215
11	1	1.74	0.04	46.00	0.0048
12	1	1.92	0.11	17.00	0.0484
13	1	2.72	0.08	36.00	0.0304
14	1	5.81	0.08	77.00	0.0649
15	1	2.53	0.08	33.50	0.0282
16	1	3.32	0.06	58.67	0.0209
17	1	2.83	0.04	75.00	0.0079
18	1	2.00	0.06	35.33	0.0126

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
19	1	2.79	0.19	14.80	0.1950
20	1	5.09	0.06	90.00	0.0320
22	1	2.15	0.04	57.00	0.0060
23	1	3.32	0.06	58.67	0.0209
24	1	7.17	0.04	190.00	0.0200
25	1	4.11	0.06	72.67	0.0258
26	1	1.89	0.06	33.33	0.0119
27	1	1.92	0.09	20.40	0.0336
28	1	1.77	0.06	31.33	0.0111
29	1	1.74	0.04	46.00	0.0048
30	1	0.75	0.04	20.00	0.0021
31	1	2.75	0.08	36.50	0.0308
32	1	2.07	0.08	27.50	0.0232
33	1	2.11	0.04	56.00	0.0059
34	1	1.85	0.08	24.50	0.0207
35	1	1.36	0.08	18.00	0.0152
36	1	4.90	0.11	43.33	0.1233
37	1	1.66	0.08	22.00	0.0186
38	1	3.02	0.04	80.00	0.0084
39	1	2.30	0.08	30.50	0.0257
40	1	1.32	0.09	14.00	0.0231
41	1	0.94	0.08	12.50	0.0105
42	1	0.75	0.04	20.00	0.0021
43	1	1.77	0.09	18.80	0.0310
44	1	1.96	0.08	26.00	0.0219
45	1	4.72	0.08	62.50	0.0527
46	1	4.87	0.08	64.50	0.0544
47	1	1.96	0.06	34.67	0.0123
48	1	0.87	0.04	23.00	0.0024
49	1	1.21	0.06	21.33	0.0076
50	1	2.38	0.04	63.00	0.0066
51	1	1.85	0.08	24.50	0.0207
52	1	2.64	0.06	46.67	0.0166
53	1	1.77	0.06	31.33	0.0111
54	1	0.79	0.08	10.50	0.0089
55	1	0.79	0.08	10.50	0.0089
56	1	6.75	0.08	89.50	0.0755
57	1	2.23	0.06	39.33	0.0140
58	1	1.74	0.08	23.00	0.0194
59	1	1.32	0.13	10.00	0.0452
60	1	1.47	0.11	13.00	0.0370
61	1	2.41	0.06	42.67	0.0152
62	1	1.51	0.15	10.00	0.0675
63	1	1.55	0.06	27.33	0.0097
64	1	0.91	0.04	24.00	0.0025
65	1	1.13	0.08	15.00	0.0126
66	1	2.68	0.04	71.00	0.0075
67	1	1.89	0.08	25.00	0.0211
68	1	2.23	0.08	29.50	0.0249
70	1	0.68	0.06	12.00	0.0043
71	1	1.47	0.08	19.50	0.0164
72	1	3.73	0.04	99.00	0.0104

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
73	1	4.94	0.15	32.75	0.2209
74	1	2.94	0.06	52.00	0.0185
75	1	2.64	0.04	70.00	0.0074
76	1	1.96	0.06	34.67	0.0123
77	1	1.92	0.23	8.50	0.1935
78	1	3.40	0.04	90.00	0.0095
79	1	1.62	0.04	43.00	0.0045
80	1	3.47	0.04	92.00	0.0097
81	1	0.87	0.08	11.50	0.0097
82	1	2.60	0.04	69.00	0.0073
83	1	2.87	0.04	76.00	0.0080
84	1	4.90	0.08	65.00	0.0548
85	1	1.74	0.08	23.00	0.0194
86	1	3.40	0.11	30.00	0.0854
87	1	4.94	0.17	29.11	0.2796
88	1	2.64	0.13	20.00	0.0904
89	1	4.15	0.06	73.33	0.0261
90	1	5.92	0.04	157.00	0.0165
91	1	2.04	0.06	36.00	0.0128
92	1	0.87	0.08	11.50	0.0097
93	1	4.60	0.06	81.33	0.0289
94	1	1.74	0.08	23.00	0.0194
96	1	1.58	0.04	42.00	0.0044
97	1	1.51	0.08	20.00	0.0169
99	1	3.47	0.04	92.00	0.0097
100	1	2.94	0.08	39.00	0.0329
101	1	8.86	0.09	94.00	0.1548
102	1	3.02	0.04	80.00	0.0084
103	1	1.58	0.04	42.00	0.0044
104	1	1.09	0.08	14.50	0.0122
105	1	2.04	0.11	18.00	0.0512
106	1	1.89	0.08	25.00	0.0211
107	1	2.34	0.04	62.00	0.0065
108	1	1.32	0.08	17.50	0.0148
110	1	2.07	0.09	22.00	0.0362
111	1	6.49	0.08	86.00	0.0725
112	1	8.45	0.04	224.00	0.0236
113	1	3.28	0.06	58.00	0.0206
114	1	2.75	0.09	29.20	0.0481
117	1	2.19	0.08	29.00	0.0245
118	1	3.09	0.15	20.50	0.1383
119	1	2.19	0.08	29.00	0.0245
121	1	1.40	0.06	24.67	0.0088

* type 1 = chrysotile asbestos

Total mass (pg) = 3.6234
Number of fibres = 113

Laboratory Sample Number: 95090285
Your Sample identification: Wolverine Creek at Tailings

Fibre concentration (Fibres per millilitre)						
All Lengths			Length > 5 µm			Detection Limit
All Fibres	All Asbestos	Chrysotile Asbestos	All Fibres	All Asbestos	Chrysotile Asbestos	
1752609.88	1739432.36	1739432.36	184485.25	184485.25	184485.25	13177.52

Asbestos Fibre Size distributions (expressed as a percent of the total)
Number of Fibres Sized = 132

Diameter (µm)	Length (µm)		
	L < 5	5 ≤ L < 8	L ≥ 8
D < 0.5	88.7	8.4	2.3
0.5 ≤ D < 3	0.8	nd	nd
D ≥ 3	nd	nd	nd

nd - none detected

Asbestos Mass Calculation - 121.00 µg per litre of water

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
1	1	1.74	0.04	46.00	0.0049
2	1	3.52	0.08	46.50	0.0397
3	1	2.42	0.04	64.00	0.0068
4	1	0.76	0.08	10.00	0.0085
5	1	1.48	0.04	39.00	0.0042
6	1	2.08	0.08	27.50	0.0235
7	1	1.78	0.11	15.67	0.0451
8	1	1.25	0.04	33.00	0.0035
9	1	1.17	0.08	15.50	0.0132
10	1	6.25	0.08	82.50	0.0704
11	1	0.57	0.08	7.50	0.0064
12	1	0.98	0.08	13.00	0.0111
13	1	0.95	0.11	8.33	0.0240
14	1	2.92	0.08	38.50	0.0329
15	1	2.95	0.11	26.00	0.0749

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
16	1	2.16	0.08	28.50	0.0243
17	1	1.21	0.11	10.67	0.0307
18	1	2.46	0.04	65.00	0.0069
19	1	1.40	0.08	18.50	0.0158
20	1	2.69	0.08	35.50	0.0303
21	1	5.61	0.08	74.00	0.0632
22	1	1.06	0.08	14.00	0.0120
23	1	0.98	0.04	26.00	0.0028
24	1	1.70	0.06	30.00	0.0108
25	1	1.21	0.09	12.80	0.0213
26	1	2.50	0.09	26.40	0.0440
27	1	11.36	0.04	300.00	0.0320
28	1	1.40	0.08	18.50	0.0158
29	1	5.72	0.06	100.67	0.0363
30	1	5.98	0.06	105.33	0.0379
31	1	3.41	0.08	45.00	0.0384
32	1	1.25	0.06	22.00	0.0079
33	1	1.89	0.08	25.00	0.0213
34	1	3.83	0.06	67.33	0.0243
35	1	1.97	0.04	52.00	0.0055
36	1	1.70	0.08	22.50	0.0192
37	1	0.64	0.06	11.33	0.0041
38	1	1.36	0.04	36.00	0.0038
39	1	1.21	0.04	32.00	0.0034
40	1	1.33	0.15	8.75	0.0598
41	1	1.14	0.11	10.00	0.0288
42	1	3.07	0.06	54.00	0.0194
43	1	0.98	0.08	13.00	0.0111
44	1	3.26	0.15	21.50	0.1468
45	1	1.52	0.06	26.67	0.0096
46	1	1.89	0.15	12.50	0.0854
47	1	1.52	0.11	13.33	0.0384
48	1	1.36	0.06	24.00	0.0086
49	1	2.27	0.57	4.00	1.4406
50	1	2.16	0.08	28.50	0.0243
51	1	1.48	0.08	19.50	0.0166
52	1	0.53	0.04	14.00	0.0015
53	1	0.57	0.06	10.00	0.0036
54	1	3.75	0.06	66.00	0.0238
55	1	1.89	0.11	16.67	0.0480
56	1	1.40	0.11	12.33	0.0355
57	1	3.30	0.04	87.00	0.0093
58	1	2.20	0.11	19.33	0.0557
59	1	10.83	0.06	190.67	0.0687
60	1	3.41	0.09	36.00	0.0600
61	1	1.25	0.04	33.00	0.0035
62	1	1.14	0.08	15.00	0.0128
63	1	0.95	0.04	25.00	0.0027
64	1	7.88	0.06	138.67	0.0499
65	1	2.88	0.15	19.00	0.1298
66	1	1.33	0.11	11.67	0.0336
67	1	1.40	0.08	18.50	0.0158

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
68	1	1.17	0.08	15.50	0.0132
69	1	6.44	0.06	113.33	0.0408
70	1	1.78	0.19	9.40	0.1254
71	1	1.86	0.06	32.67	0.0118
72	1	2.16	0.11	19.00	0.0547
73	1	7.23	0.04	191.00	0.0204
74	1	1.33	0.08	17.50	0.0149
75	1	6.10	0.09	64.40	0.1074
76	1	1.69	0.15	11.13	0.0760
77	1	1.25	0.08	16.50	0.0141
78	1	0.83	0.08	11.00	0.0094
79	1	1.40	0.09	14.80	0.0247
80	1	8.71	0.08	115.00	0.0982
81	1	1.17	0.08	15.50	0.0132
82	1	1.70	0.11	15.00	0.0432
83	1	1.82	0.04	48.00	0.0051
84	1	1.52	0.09	16.00	0.0267
85	1	1.33	0.08	17.50	0.0149
86	1	3.18	0.08	42.00	0.0359
87	1	1.59	0.13	12.00	0.0549
88	1	1.17	0.08	15.50	0.0132
89	1	2.80	0.09	29.60	0.0494
90	1	1.59	0.04	42.00	0.0045
91	1	4.28	0.21	20.55	0.3648
93	1	1.02	0.04	27.00	0.0029
94	1	0.57	0.06	10.00	0.0036
95	1	0.38	0.08	5.00	0.0043
96	1	7.95	0.45	17.50	3.2270
97	1	1.59	0.06	28.00	0.0101
98	1	5.68	0.06	100.00	0.0360
99	1	1.25	0.04	33.00	0.0035
100	1	1.97	0.08	26.00	0.0222
101	1	0.83	0.08	11.00	0.0094
102	1	1.40	0.06	24.67	0.0089
103	1	1.40	0.06	24.67	0.0089
104	1	6.33	0.06	111.33	0.0401
105	1	1.25	0.08	16.50	0.0141
106	1	2.27	0.04	60.00	0.0064
107	1	0.98	0.04	26.00	0.0028
108	1	1.33	0.04	35.00	0.0037
109	1	0.64	0.04	17.00	0.0018
110	1	2.80	0.09	29.60	0.0494
111	1	1.14	0.04	30.00	0.0032
112	1	2.88	0.30	9.50	0.5191
113	1	2.65	0.11	23.33	0.0672
114	1	2.46	0.04	65.00	0.0069
115	1	1.40	0.04	37.00	0.0039
116	1	1.59	0.08	21.00	0.0179
117	1	2.92	0.09	30.80	0.0514
118	1	1.10	0.08	14.50	0.0124
119	1	1.67	0.08	22.00	0.0188
120	1	1.67	0.09	17.60	0.0293

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
121	1	1.63	0.08	21.50	0.0184
122	1	2.99	0.08	39.50	0.0337
123	1	0.98	0.04	26.00	0.0028
124	1	1.10	0.08	14.50	0.0124
125	1	3.94	0.11	34.67	0.0999
126	1	1.17	0.04	31.00	0.0033
127	1	0.76	0.06	13.33	0.0048
128	1	0.91	0.08	12.00	0.0102
129	1	2.84	0.19	15.00	0.2001
130	1	1.06	0.11	9.33	0.0269
131	1	0.91	0.08	12.00	0.0102
132	1	0.87	0.08	11.50	0.0098
133	1	0.95	0.04	25.00	0.0027

* type 1 = chrysotile asbestos

Total mass (pg) = 9.1823
Number of fibres = 132

Laboratory Sample Number: 95090286
Your Sample identification: Clinton/Wolverine at Confluence

Fibre concentration (Fibres per millilitre)						
All Lengths			Length > 5 μm			Detection Limit
All Fibres	All Asbestos	Chrysotile Asbestos	All Fibres	All Asbestos	Chrysotile Asbestos	
142933900.76	142933900.76	142933900.76	37718668.26	37718668.26	37718668.26	661731.02

Asbestos Fibre Size distributions (expressed as a percent of the total)
Number of Fibres Sized = 216

Diameter (μm)	Length (μm)		
	L < 5	5 ≤ L < 8	L ≥ 8
D < 0.5	73.7	14.9	11.6
0.5 ≤ D < 3	nd	nd	nd
D ≥ 3	nd	nd	nd

nd - none detected

Asbestos Mass Calculation - 5568.93 μg per litre of water

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
1	1	1.97	0.06	34.67	0.0125
2	1	1.48	0.06	26.00	0.0094
3	1	2.84	0.06	50.00	0.0180
4	1	3.03	0.09	32.00	0.0534
5	1	2.31	0.11	20.33	0.0586
6	1	3.64	0.06	64.00	0.0231
7	1	1.89	0.04	50.00	0.0053
8	1	1.33	0.04	35.00	0.0037
9	1	6.93	0.04	183.00	0.0195
10	1	0.87	0.08	11.50	0.0098
11	1	6.44	0.04	170.00	0.0181
12	1	6.44	0.04	170.00	0.0181
13	1	4.05	0.11	35.67	0.1028
14	1	3.41	0.08	45.00	0.0384
15	1	0.91	0.04	24.00	0.0026
16	1	2.08	0.04	55.00	0.0059

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
17	1	3.52	0.06	62.00	0.0223
18	1	1.82	0.11	16.00	0.0461
19	1	1.33	0.08	17.50	0.0149
20	1	1.44	0.08	19.00	0.0162
21	1	6.06	0.04	160.00	0.0171
22	1	2.08	0.08	27.50	0.0235
23	1	5.53	0.06	97.33	0.0351
24	1	3.79	0.08	50.00	0.0427
25	1	3.56	0.04	94.00	0.0100
26	1	0.95	0.08	12.50	0.0107
27	1	3.67	0.04	97.00	0.0104
28	1	15.15	0.04	400.00	0.0427
29	1	1.82	0.11	16.00	0.0461
30	1	0.95	0.04	25.00	0.0027
31	1	0.72	0.08	9.50	0.0081
32	1	1.21	0.04	32.00	0.0034
33	1	5.30	0.08	70.00	0.0598
34	1	5.64	0.04	149.00	0.0159
35	1	5.30	0.04	140.00	0.0149
36	1	4.85	0.04	128.00	0.0137
37	1	2.23	0.08	29.50	0.0252
38	1	13.98	0.04	369.00	0.0394
39	1	1.86	0.11	16.33	0.0471
40	1	11.74	0.04	310.00	0.0331
41	1	3.60	0.04	95.00	0.0101
42	1	0.91	0.06	16.00	0.0058
43	1	3.56	0.04	94.00	0.0100
44	1	3.83	0.08	50.50	0.0431
45	1	7.73	0.04	204.00	0.0218
46	1	0.83	0.08	11.00	0.0094
47	1	2.46	0.04	65.00	0.0069
48	1	7.42	0.04	196.00	0.0209
49	1	1.36	0.04	36.00	0.0038
50	1	3.03	0.04	80.00	0.0085
51	1	17.05	0.04	450.00	0.0480
52	1	32.20	0.04	850.00	0.0907
53	1	1.93	0.06	34.00	0.0122
54	1	1.89	0.08	25.00	0.0213
55	1	2.88	0.06	50.67	0.0182
56	1	3.26	0.04	86.00	0.0092
57	1	0.87	0.08	11.50	0.0098
58	1	0.98	0.06	17.33	0.0062
59	1	2.95	0.04	78.00	0.0083
60	1	7.80	0.06	137.33	0.0495
61	1	2.35	0.09	24.80	0.0414
62	1	3.67	0.11	32.33	0.0932
63	1	3.33	0.04	88.00	0.0094
64	1	7.95	0.08	105.00	0.0896
65	1	2.05	0.08	27.00	0.0231
66	1	3.30	0.04	87.00	0.0093
67	1	7.42	0.13	56.00	0.2562
68	1	3.03	0.04	80.00	0.0085

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
69	1	4.70	0.04	124.00	0.0132
70	1	2.16	0.08	28.50	0.0243
71	1	0.83	0.08	11.00	0.0094
72	1	2.39	0.04	63.00	0.0067
73	1	2.27	0.06	40.00	0.0144
74	1	2.01	0.08	26.50	0.0226
75	1	1.52	0.09	16.00	0.0267
76	1	2.58	0.11	22.67	0.0653
77	1	6.82	0.04	180.00	0.0192
78	1	3.07	0.04	81.00	0.0086
79	1	10.42	0.04	275.00	0.0293
80	1	12.12	0.04	320.00	0.0341
81	1	1.97	0.04	52.00	0.0055
82	1	2.05	0.04	54.00	0.0058
83	1	1.52	0.06	26.67	0.0096
84	1	6.29	0.04	166.00	0.0177
85	1	21.59	0.04	570.00	0.0608
86	1	2.35	0.04	62.00	0.0066
87	1	1.44	0.08	19.00	0.0162
88	1	2.61	0.04	69.00	0.0074
89	1	3.07	0.04	81.00	0.0086
90	1	2.12	0.04	56.00	0.0060
91	1	2.12	0.04	56.00	0.0060
92	1	2.50	0.04	66.00	0.0070
93	1	2.35	0.04	62.00	0.0066
94	1	1.33	0.09	14.00	0.0233
95	1	8.94	0.04	236.00	0.0252
96	1	5.42	0.04	143.00	0.0153
97	1	5.98	0.04	158.00	0.0169
98	1	2.01	0.04	53.00	0.0057
99	1	4.73	0.04	125.00	0.0133
100	1	7.01	0.04	185.00	0.0197
101	1	3.86	0.04	102.00	0.0109
102	1	5.42	0.04	143.00	0.0153
103	1	1.21	0.06	21.33	0.0077
104	1	0.68	0.06	12.00	0.0043
105	1	1.14	0.06	20.00	0.0072
106	1	3.37	0.06	59.33	0.0214
107	1	4.81	0.06	84.67	0.0305
108	1	6.06	0.04	160.00	0.0171
109	1	12.50	0.04	330.00	0.0352
110	1	2.92	0.02	154.00	0.0021
111	1	5.30	0.04	140.00	0.0149
112	1	1.14	0.02	60.00	0.0008
113	1	4.24	0.04	112.00	0.0120
114	1	7.20	0.04	190.00	0.0203
115	1	4.09	0.04	108.00	0.0115
116	1	12.12	0.04	320.00	0.0341
117	1	1.74	0.08	23.00	0.0196
118	1	2.65	0.04	70.00	0.0075
119	1	2.65	0.08	35.00	0.0299
120	1	2.95	0.02	156.00	0.0021

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
121	1	6.82	0.04	180.00	0.0192
122	1	3.45	0.04	91.00	0.0097
123	1	54.43	0.11	479.00	1.3801
124	1	1.36	0.08	18.00	0.0154
125	1	4.92	0.04	130.00	0.0139
126	1	3.94	0.04	104.00	0.0111
127	1	1.52	0.04	40.00	0.0043
128	1	3.33	0.04	88.00	0.0094
129	1	12.88	0.04	340.00	0.0363
130	1	19.55	0.04	516.00	0.0551
131	1	6.06	0.04	160.00	0.0171
132	1	1.74	0.04	46.00	0.0049
133	1	4.55	0.04	120.00	0.0128
134	1	17.61	0.04	465.00	0.0496
135	1	2.65	0.04	70.00	0.0075
136	1	1.25	0.08	16.50	0.0141
137	1	1.17	0.08	15.50	0.0132
138	1	3.18	0.11	28.00	0.0807
139	1	1.52	0.08	20.00	0.0171
140	1	12.88	0.04	340.00	0.0363
141	1	5.80	0.09	61.20	0.1020
142	1	12.88	0.06	226.67	0.0816
143	1	1.74	0.27	6.57	0.2405
144	1	3.03	0.04	80.00	0.0085
145	1	4.73	0.04	125.00	0.0133
146	1	2.12	0.08	28.00	0.0239
147	1	4.43	0.11	39.00	0.1124
148	1	0.87	0.04	23.00	0.0025
149	1	0.57	0.08	7.50	0.0064
150	1	1.21	0.11	10.67	0.0307
151	1	2.01	0.11	17.67	0.0509
152	1	2.16	0.04	57.00	0.0061
153	1	7.23	0.04	191.00	0.0204
154	1	2.05	0.11	18.00	0.0519
155	1	1.82	0.04	48.00	0.0051
156	1	1.55	0.02	82.00	0.0011
157	1	11.36	0.04	300.00	0.0320
158	1	5.61	0.04	148.00	0.0158
159	1	11.36	0.06	200.00	0.0720
160	1	2.08	0.38	5.50	0.5869
161	1	27.08	0.04	715.00	0.0763
162	1	6.25	0.08	82.50	0.0704
163	1	1.89	0.04	50.00	0.0053
164	1	2.31	0.04	61.00	0.0065
165	1	4.36	0.02	230.00	0.0031
166	1	2.08	0.02	110.00	0.0015
167	1	0.83	0.04	22.00	0.0023
168	1	2.23	0.09	23.60	0.0394
169	1	3.86	0.08	51.00	0.0435
170	1	3.26	0.27	12.29	0.4497
171	1	0.80	0.08	10.50	0.0090
172	1	1.59	0.11	14.00	0.0403

Rec#	Type*	Length (um)	Width (um)	Aspect Ratio	Mass (pg)
173	1	3.30	0.04	87.00	0.0093
174	1	5.08	0.04	134.00	0.0143
175	1	4.77	0.04	126.00	0.0134
176	1	1.82	0.08	24.00	0.0205
177	1	0.98	0.04	26.00	0.0028
178	1	1.55	0.08	20.50	0.0175
179	1	9.66	0.08	127.50	0.1088
180	1	3.18	0.08	42.00	0.0359
181	1	0.76	0.08	10.00	0.0085
182	1	0.68	0.04	18.00	0.0019
183	1	2.84	0.08	37.50	0.0320
184	1	2.23	0.02	118.00	0.0016
185	1	3.79	0.08	50.00	0.0427
186	1	2.08	0.08	27.50	0.0235
187	1	0.72	0.04	19.00	0.0020
188	1	1.33	0.15	8.75	0.0598
189	1	2.58	0.06	45.33	0.0163
190	1	5.30	0.04	140.00	0.0149
191	1	2.35	0.04	62.00	0.0066
192	1	3.41	0.15	22.50	0.1537
193	1	5.80	0.06	102.00	0.0367
194	1	5.76	0.04	152.00	0.0162
195	1	2.61	0.02	138.00	0.0018
196	1	2.12	0.02	112.00	0.0015
197	1	1.52	0.04	40.00	0.0043
198	1	8.60	0.08	113.50	0.0969
199	1	23.33	0.08	308.00	0.2629
200	1	3.11	0.04	82.00	0.0088
201	1	0.61	0.08	8.00	0.0068
202	1	1.44	0.19	7.60	0.1014
203	1	14.89	0.06	262.00	0.0944
204	1	4.02	0.06	70.67	0.0255
205	1	3.14	0.04	83.00	0.0089
206	1	9.02	0.02	476.00	0.0063
207	1	3.52	0.04	93.00	0.0099
208	1	2.35	0.04	62.00	0.0066
209	1	0.83	0.04	22.00	0.0023
210	1	4.43	0.04	117.00	0.0125
211	1	1.44	0.04	38.00	0.0041
212	1	0.87	0.06	15.33	0.0055
213	1	0.95	0.04	25.00	0.0027
214	1	1.29	0.02	68.00	0.0009
215	1	3.64	0.04	96.00	0.0102
216	1	2.01	0.27	7.57	0.2771

* type 1 = chrysotile asbestos

Total mass (pg) = 8.4157
Number of fibres = 216

Method: Analytical Transmission Electron Microscopy, Occupational Health Laboratory Method Number 014 (See Appendix I)

Detection Limit: One confirmed asbestos fibre above the blank mean. See the fibre concentration tables for individual detection limits.

Analyst: ____________________
Nancy Clark, B.Sc.
Research Assistant

Checked: ____________________
Lorraine Shaw, B.Sc., CIH, ROH
Laboratory Co-ordinator

Reviewed and Approved by: ____________________
Dave K. Verma, Ph.D., P.Eng., CIH, ROH
Laboratory Director

/as

Appendix I

Method

Each sample was agitated prior to filtration through a 0.1 μm pore size 47 mm diameter mixed cellulose ester filter (vc filter). Aliquots ranging from 1 ml to 200 ml were filtered for each sample. Two of the filters for each sample were processed further. The two chosen depended upon the sample loading (filtration time and visible material on the filter). Double deionized, distilled water was filtered through a vc filter and used for all sample preparation. Five hundred (500) ml of the same water was filtered through a vc filter and used as a laboratory blank. No asbestos fibres were found on the blank sample.

Samples 95090285 and 95090286 were overloaded with fibres and particulate upon ATEM examination. These samples were re-filtered using 0.2 ml and 0.5 ml aliquots.

The filters were ashed in a low temperature plasma asher overnight to remove organic matter from the samples. The ash was suspended in filtered, double deionized, distilled water and sonicated in a low power sonicator. The suspension was then suction filtered through a vc filter. The filters were allowed to dry overnight at ambient temperatures.

The five samples plus the blank were processed in the following manner:

The filters were divided into eight equal wedges. Four of these were randomly selected for analytical transmission electron microscope (ATEM) analysis.

The wedges were affixed to a clean glass microscope slide with transparent tape and the filter matrix was collapsed with acetone vapour. The samples were then coated with a 20 to 30 nanometer thick layer of carbon using an Edwards vacuum evaporator. The filter was dissolved away with acetone in a condensation washer depositing the sample onto a 200 mesh nickel finder's grid.

The first two grids with at least seventy-five percent of the carbon film intact were used for the analyses. Ten grid openings on each grid were randomly selected and photographed at approximately 1000X magnification using a JEOL 1200EX ATEM. A contact print was made of each negative.

Each negative was scanned at approximately 27X magnification with a Jena microfilm reader. The final magnification of the negatives was 26509X for samples 95090282, 95090283 and 95090284 and 26400X for samples 95090285 and 95090286. Every fibre was measured with respect to its length and diameter and its position marked on the contact print.

X-ray analysis was performed on every fibre providing an elemental analysis. With this method, possible fibre identifications were: chrysotile, amosite, crocidolite and other.

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