# BLM Employee Exposure to Naturally Occurring Asbestos at the Clear Creek Management Area and the Knoxville Management Area

**U.S. Department of the Interior**
**Office of Occupational Health and Safety**


**May 2008**

## EXECUTIVE SUMMARY

**Employee exposures to naturally occurring asbestos at the Clear Creek Management Area were monitored on 4 occasions by the DOI Office of Occupational Health and Safety. A total of 89 samples were collected representing 429 work hours. Eight hour time-weighted average exposures were determined. The results showed exposures varied by job task with the highest exposures during the SWECO operation, the sign installation, water truck operation. One 8-hr time-weighted average exposure during the SWECO operation exceeded the OSHA Permissible Exposure Limit (PEL). This report includes recommendations to limit employee exposures by engineering, work practice, and administrative controls to ensure exposures do not exceed the PEL. A cancer risk assessment tool is proposed for determining the number of work days permitted to stay below an acceptable risk level.**

**Measured exposures and the calculated cancer risk levels at the Knoxville Management Area were an order of magnitude lower than those at the Clear Creek Management Area. This is due to the lower measured concentrations and the small number of days employees are on-site. Several recommendations are specified to further reduce these exposures.**

## INTRODUCTION

This report focuses on BLM employee exposure to asbestos at the Clear Creek Management Area (CCMA), San Benito County which is managed by the Hollister Field Office and the Knoxville Management Area in Napa County California, managed by the Ukiah Field Office. It does not address public exposures during recreational activities at these sites. Exposure to the public is address in the EPA Risk Assessment Report dated February 2008 and is part of this report.

**Objectives:**

- To estimate employee exposure to naturally occurring asbestos during tasks performed by BLM employees during various environmental conditions using accepted industrial hygiene practices.
- Validate methods used by BLM to monitor employees' exposures. This included training employees on proper sampling techniques and providing CIH oversight and guidance to an ongoing "in house" personal air monitoring program .

Naturally occurring asbestos (NOA) on BLM managed land has been recognized as a potential exposure issue since the late 1970's. Since the early 1960's three asbestos mines have operated in the CCMA with the last mine closing in 1998. The Atlas Mine operated until 1979 and has been managed as a Superfund site since 1989. Since that time personal exposure monitoring has been conducted on employees working on the Clear Creek Site.

CCMA visitor days average around 5000 per month from October through May. Since 2005 BLM has instituted a "dry season closure" where usage is limited during the dry summer months.

According to BLM, soil concentrations throughout the Clear Creek Management Area ranged from trace levels in darker soils with higher organic material to 40% asbestos in the lighter colored sparsely vegetated soils. Although chrysotile is the predominant type of asbestos mineral present, some amphibole was detected in the air samples which were analyzed by transmission electron microscopy (TEM).

Sampling was conducted on four occasions during differing environmental conditions. According to the work descriptions, most work activity at Clear Creek takes

place in January through April. Employees spend varying number of workdays at the Clear Creek Site and are assigned through the Hollister District Office. Other than the law enforcement personnel, employees work at the Knoxville site in the range of 5 to 10 days per year.

**METHODS:**

In this survey, standard industrial hygiene monitoring methods were used to characterize exposures during various work activities at 4 different times of the year. Samples were analyzed by Phase Contrast Microscopy (PCM) using NIOSH 7400 method. Additionally, samples analyzed by the NIOSH 7400 method whose 8-hr time-weighted averaged exceeded ½ of the OSHA permissible exposure limit were analyzed by TEM to determine the percent asbestos of the constituent fibers. This factor was then applied to the PCM count to give a more accurate count of asbestos fibers. The last round of sampling was analyzed by PCM NIOSH 7400, TEM NIOSH 7402 method; and by TEM International Standard Organization ISO 10312 method. Reservoirs Environmental, Inc is the analytical laboratory used in this survey. It is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP), and the American Industrial Hygiene Association (AIHA) PAT program.

High flow personal air sampling pumps were calibrated at 2 liters per minute prior to sampling and after sampling. The calibrator met the requirements for current annual factory calibration check. Twenty-five millimeter diameter electrically conductive cowled cassettes using 0.8 μm pore size mixed cellulose ester filters were connected via tygon tubing to the pump. The complete sampling train was used during calibration including use of a filter cassette from the lot of filters to be used in the field. Three separate calibration reading were obtained both before sampling and after sampling.

In all cases the filter was placed within the employees' breathing zones with the filter faced in a downward position. During sampling in the field, rotometers on the pumps were checked to determine constant flow during the sampling period. Filter overloading was not a problem during any of the sampling events. During times of potentially high exposures, excursion limit samples were taken for a thirty minute period for comparison to the 1.0 fiber per cubic centimeter excursion limit. The air sampling

was started at the CCMA decon facility where employee report to work before entering the contaminated area. This site is approximately 20-30 minutes from the contaminated zone. This travel time to the site is part of the employees work shift and is therefore included in the eight hour time-weighted average exposure.

General weather conditions were recorded along with temperature and humidity and wind speed readings using a hot wire anemometer to characterize environmental conditions during the sampling.

BLM has been conducting personal exposure monitoring on employees since the early 1990's. A recent OSHA inspection identified some issues with past employee exposure monitoring methods and it was determined that a new evaluation of employee exposures be conducted. Throughout this period there have been some irregularities in sampling methods such as using a primary calibrator that had an expired lab certification, and some reports of not sampling with open-faced filter cassettes. The samples were all analyzed using PCM. The quality control of the laboratory was not verified. Recognizing the irregularities in the sampling methods, the data gives an indication of general exposure levels for particular jobs over past 18 years. While it is not the purpose of this report to analyze the historic data set, this data gives an indication of general exposure concentrations over the past 18 years. The overall mean 8hr time-weighted average exposure for the data set was 0.018 f/cc. Thirteen (1%) of the 1271 samples exceeded the PEL of 0.1 f/cc for 8 hr time-weighted average exposures.

EPA has completed an evaluation of exposures for various public use activities including motorcycle, SUV, ATV, hiking, camping. The report also addressed the differences between adult and child exposure and cancer risk. These risk assessment methods provide calculations of cancer risk for the specific activities over a lifetime. It differs from the occupational exposure assessment in that it does not correspond to a specific allowable airborne concentration for a specified time.

It is important to understand the different processes determining courses of action to protect both the employee and the public. Occupational exposures are regulated by an existing standard established by OSHA. This is the law which regulated all occupational exposures to asbestos in the United States. It should be noted that OSHA has modified the standard several times in response to new information about health risk from

exposure. The 0.1 f/cc PEL has been in place since 1994, and there is currently an interagency workgroup looking at research needs to further the knowledge base on asbestos toxicity. Occupational exposures throughout all workplaces use the OSHA PEL of 0.1 f/cc for an 8-hr time-weighted average exposure. The American Conference of Governmental Industrial Hygienists is a non-regulatory standard setting organization and uses 0.1 f/cc as their 8-hr TWA threshold limit value. The occupational exposure limits are established to protect a healthy working aged adult. In establishing these standards OSHA also considers the protection from adverse health outcomes as well as the impact of the regulation on the industry. In determining the risk to the public, EPA considers all age groups including the most susceptible portions of the population. The decision how much risk is acceptable also differs when considering the general population. EPA decisions are based on a acceptable risk level of 1 in 10,000 excess cancer cases. Historically, occupational standards assume a higher level of risk because of the "healthy worker" effect.

Sampling was conducted on routine work being performed at the time of the site-visit. The fence crews made up the largest workforce during the site visits and thus resulted in the most samples collected. Work varied and included hand digging post holes, operating auger, setting posts. Visits were spread over the course of the year and in differing moisture conditions. No sampling was performed during the dry season closure. Sampling was conducted during their time spent on the worksite. Since they are full work shift samples, these results represent the actual exposure the employee is experiencing during the entire work shift and does not rely on piecing together activity based exposures.

The 87 samples correspond to 429 hours of sampling time on the actual workers who routinely perform the activities below. Full shift sampling provides exposure information for all activities performed during the work-shift. For example, during motorcycle patrol, the rider will have different exposure situations such as whether they are leading or trailing a vehicle. This full-shift sampling gives a time-weighted average of all the exposure components during the work-shift and does not rely on piecing together exposures for individual activities. It is the accepted method of measuring occupational exposures and is the basis for occupational exposure limits.

**Sample Number and Activity**

| Activity | Samples at Clear Creek | Samples at Knoxville | Total |
|---|---|---|---|
| Motorcycle monitoring/patrol | 9 | 0 | 9 |
| Decontaminating vehicles | 2 | 0 | 2 |
| Water Truck Operation | 1 | 0 | 1 |
| Campground and Restroom Cleaning | 4 | 2 | 6 |
| Campground Area Sample | 2 | 0 | 2 |
| Entrance Station Operation | 3 | 0 | 3 |
| ATV Monitoring/Patrol | 5 | 0 | 5 |
| Fence Crew | 23 | 0 | 23 |
| Hiking/misc activity | 6 | 0 | 5 |
| SWECO trail grader | 6 | 2 | 9 |
| Sign Installation | 5 | 0 | 5 |
| LE Patrol Truck/SUV | 1 | 2 | 3 |
| Pickup truck within red zone | 1 | 0 | 1 |
| Decon | 1 | 0 | 1 |
| Heavy Equipment Operation (Dozer, backhoe, grader) | 5 | 4 | 9 |
| Transit To and From Office | 3 | 2 | 5 |
| **Total** | **77 (369 hrs)** | **12 (60 hrs)** | **89 (429 hrs)** |

## CLEAR CREEK RESULTS AND DISCUSSION

Composite time-weighted averages give weighting to the sampling time for each result, therefore giving a true average exposure over the total number of minutes sampled. Taking the mean of the filter results would not give weight to those samples that correspond to a longer sampling time, but gives all results the same weighting, therefore time-weighted averages must be used for determining occupational exposures.

Eight hour time-weighted averages were calculated for each employee monitored. This approach averages the exposure over an entire 8-hr work shift regardless of the

amount of time in the contaminated area. For example, if a worker spends 6 hours in the contaminated work site and 2 hours away from the contamination:

$$\frac{(6 \text{ hrs x exposure in contam. work area}) + (2 \text{ hrs x exposure in outside area})}{8 \text{ hrs}} = \text{8-hr TWA}$$

Occupational exposure limits such as the OSHA PEL are based on the concept of the 8-hour TWA. Assuming the exposure time outside of the contaminated area is less than the exposures in the red zone, the 8-hour TWA will always be at or lower than the TWA for the time sampled. Sample results during the time away from the CCMA site, such as the travel to and from the site, were below the limit of detection. Detection limits varied depending on sampling time, but for the full 8-hr work shift sampling periods sampling at 2 liters per minute, the detection limit was 0.003 fibers/cc. The short term (30 minute) sampling had a detection limit of approximately 0.04 fibers/cc.

**Clear Creek Sample Results**

| **Activity** | **Number of Samples** | **Composite time-weighted average (total sampling time)** | **Mean of 8-hr time-weighted average exposures** |
|---|---|---|---|
| Motorcycle monitoring/patrol | 9 | 0.026 | 0.017 |
| Water Truck Operation | 1 | 0.039 | 0.025 |
| Campground and Restroom Cleaning | 4 | 0.021 | <0.009 |
| Campground Area Sample | 2 | BDL(.007) | |
| Entrance Station Operation | 3 | 0.020 | 0.012 |
| ATV Monitoring/Patrol | 5 | 0.033 | <0.017 |
| Fence Crew | 23 | 0.017 | 0.015 |
| Habitat Monitoring Hiking/misc activity | 6 | 0.014 | <0.010 |
| SWECO trail grader | 6 | 0.061 | 0.054 |
| Sign Installation | 5 | 0.026 | 0.022 |
| LE Patrol Truck/SUV | 1 | BDL(.008) | BDL |
| Decon (30 minute STEL) | 1 | BDL(.045) | |
| Heavy Equipment Operation (Dozer, backhoe, grader) | 5 | 0.012 | 0.011 |
| Transit in Pickup Truck From Hollister to CCMA Office | 3 | BDL(0.020 – 0.015) | BDL |
| Transit in pickup truck within red zone. | 1 | 0.011 | 0.011 |

BDL: below detection limit

The highest exposure at the CCMA was during the SWECO operation. The SWECO machine is a tracked trail grader with an enclosed cab with HEPA filtration. The operator spends most of the day in the vehicle but on several occasions had to perform maintenance work on the equipment. During the sampling dates the SWECO would be stored in the red zone for use the following day. HEPA vacuuming of the cab was not routinely done. Sampling conducted in March 2007 during the extreme dry conditions resulted in an exposure at the OSHA PEL of 0.1f/cc. At that time the operator was quoted as "never seeing such dry conditions" and that "if this doesn't blow the sample, nothing will". The subsequent results showed that the samples were at the OSHA PEL. This indicates that the operator is able to identify the extreme situations to avoid operation of the SWECO during these periods. SWECO trail maintenance should never be performed during extremely dry conditions. HEPA vacuum the SWECO cab after each work shift.

The mean 8-hr TWA for sign installers was 0.022 f/cc. The highest exposures for sign installer were on the high traffic day of sampling. The most frequent task for sign installers is manually driving in the flexible reflector posts on the road side. They are in close proximity to the roadbed where exposures may be more likely due to the high traffic volume rather than the dust generated by installing the signs. Replacing the deteriorating fiberglass posts may result in glass fibers being counted on the PCM analysis. This task should be restricted to days with low traffic volume.

A separate short term exposure sample taken during decontamination of the vehicle showed a concentration less than the detection limit. A microvac sample of the motorcycle following decontamination showed 7% chrysotile in the remaining debris after cleaning. This shows that decontamination procedures do not remove all of the asbestos material. This is not surprising, but can be an educational tool for employees that decon is effective, but asbestos can still be present following cleaning. This indicates the need to thoroughly decontaminate equipment.

The decontamination station is currently located 15-20 minutes away from the contaminated area. The clean and dirty areas are not currently separated and employees exit the shower area back into the "dirty" or pre-decon area. The office space is also

accessed by employees returning from the red zone prior to decon. Ideally, the areas should be located adjacent to the contaminated zone and the traffic flow should require crossing the decon pad to enter the "clean area". Employees should also enter the shower facility on the pre-decon side and remove coveralls and shower then enter the "clean side of the locker room and exit into the clean area. Some form of barricade or fence should separate the clean area from the dirty area. The office area with the sampling equipment should be only accessible on the clean side.

It was difficult to characterize soil moisture conditions. The use of the soil moisture meter was ineffective in characterizing the soil moisture conditions. The variability of the readings depending on location and the lack of precision of the meter made it an ineffective tool for the purposes of this assessment. Soil moisture varied greatly on north versus south facing slopes and trails. We depended on qualitative judgment of soil and environmental conditions. Using the mean concentration for the time sampled during the particular sampling trips showed a general relationship with the qualitative environmental conditions. This suggests that employees may be able to qualitatively judge and avoid extreme conditions. From discussions with employees however, dry and extreme conditions may occur at any time of the year. It should be noted that seasonal differences in asbestos concentration were not statistically significant for the PTI study. EPA also suggested no relation between season and exposure concentration, however most of their sampling was conducted in dry conditions.

**Environmental Conditions**

| **Qualitative Assessment of Environmental Conditions at Clear Creek** | **Date** | **Number of Samples (all activities)** | **Mean PCM Concentration for Time Sampled (f/cc)** |
|---|---|---|---|
| Moderate soil moisture; 50 -60% RH; 45-55° F; moderate wind; low traffic | Jan/Feb 2007 | 14 | 0.013 |
| Dry/dusty; low wind; high traffic | March 2007 | 29 | 0.023 |
| Extremely dry; low soil moisture; low to moderate wind; low traffic rH 8.1%; 90 F; | May 2007 | 11 | 0.049 |
| Moderate soil moisture; moderate | Feb 2008 | 13 | 0.012 |

| | | | |
|---|---|---|---|
| wind; low traffic, rH 25%; 70-75 F; | | | |

Not including 30 minute excursion samples
Detection limit was used in the mean for samples that were BDL

Four of the 89 samples were subsequently analyzed by TEM to determine the percent asbestos fibers on the filter. The percentages varied from 86% (motorcycle patrol); 90% (ATV patrol); 86.6% (SWECO); 28.6% (SWECO). These percentages could be applied to the PCM count. The last round of sampling was analyzed by the TEM NIOSH 7402 method and the ISO 10312 method and reported Phase Contrast Microscopy Equivalent PCME fiber counts. Although these methods are counting fibers greater than 5 microns with 3:1 aspect ratio and a diameter greater than .25 microns, they use differing counting rules for bundles and clusters of fibers. The table below shows the variability in the results from the differing methods. The ISO method uses different rules for counting bundles and clusters. It also is looking at a much smaller area of the filter. This may account for the differences from the PCM results. The NIOSH 7402 method mimics the PCM counting rules but is able to differentiate asbestos from non-asbestos fibers. The NIOSH 7402 PCME results are more likely to be similar to the PCM counts.

Along with the PCME fiber counts, the ISO 10312 method also reports total asbestos structures detected. The results show only 2.8% of the total structures detected met the PCME definition. Most structures detected were associated with complex structures, were shorter than 5 microns, or had aspect ratios of less than 3:1.

**PCM NIOSH 7400A / NIOSH 7402 / IOS 10312 Comparison**

| Sample Activity | PCM 7400 | NIOSH 7402 PCME | IOS 10312 PCME |
|---|---|---|---|
| Backhoe/fencing | 0.007 | 0.0142 | 0.0644 |
| ATV monitoring | 0.019 | 0.0229 | 0.077 |
| Restroom Cleaning | 0.016 | 0.0517 | 0.0517 |
| SWECO | 0.011 | 0.0124 | 0.0068 |
| Truck in Red Zone | 0.011 | 0.0167 | 0.0402 |
| Truck to Hollister | BDL | BDL | BDL |
| Truck to Residence | BDL | BDL | BDL |
| Fence work | BDL | 0.0064 | BDL |

| | | | |
|---|---|---|---|
| Campground Area Sample | BDL | 0.0067 | 0.0088 |
| Campground Area Sample | BDL | BDL | BDL |

**Sampling procedure review**

During the first site visit, the calibration and sampling procedures were reviewed the BLM personnel responsible for coordinating the sampling. Emphasis was placed on the use of open-faced cassettes and on keeping the calibrator current on factory calibration check. Exposures should be evaluated based on the running mean of the particular employee/task and less emphasis placed on the upper confidence limit as a decision making endpoint. Employee personal exposure monitoring should continue using PCM as the analytical method since occupational exposure limits and health outcome data including the EPA unit risk factor are based on this method of analysis.

Although not strictly required by the OSHA standard at these exposure levels, the employees should continue in the medical surveillance and respiratory protection programs. Unanticipated job tasks with potential for high exposure may arise which would be prudent for employees to wear respirators to reduce exposures.

## KNOXVILLE RESULTS AND DISCUSSION

Operations at the Knoxville site are very limited with maintenance activities occurring 5 to 10 days per year. Law enforcement patrols occur more frequently, however employee exposures never exceeded a quarter of the PEL. Highest exposures resulted in dry sweeping cement pads in campgrounds and sweeping restrooms and during transit to and from worksite. Recommendations include HEPA vacuuming cabs of heavy equipment and of vehicles. Dry sweeping of campground pads and of restroom floors should be eliminated and replaced with hosing off with water. The exposures measured on the open cab SWECO were unexpectedly low. This was a very dusty operation and on both samples the asbestos exposures were low. Higher than expected levels were found in the vehicles used for transport to and from the site and in most cases these levels exceeded what was measured during the work at the Knoxville site. Because of the lower exposure concentration and the lower frequency of the on-site work, the risk calculations for employees do not indicate risk levels greater than the 1 in 10000 at the

Knoxville site based on the PCM data collected. If frequency of on-site work increases in the Knoxville site, the occupational risk should be recalculated. Exposure to the public was not evaluated in this report, but since on-site work exposures were considerably lower than that at Clear Creek, public exposure is expected to also be lower.

With the smaller number of samples taken and the low exposure levels during the on-site work time, we saw no apparent correlation with airborne concentration and qualitative environmental conditions for the Knoxville site.

Recommendations for Knoxville:

- Eliminate dry sweeping of camping pads and restrooms.
- Routinely HEPA vacuum vehicles used to transport employees to and from the worksite.
- Routinely HEPA vacuum heavy equipment cabs.

**Knoxville Results:**

| Task | Date | Conditions | Sampling Time (minutes) | TWA for Time Sampled (f/cc) | 8-hr TWA (f/cc) |
|---|---|---|---|---|---|
| LE Patrol Truck (window open) | 5/24 | Low soil moisture; Very dry/dusty; low to moderate wind; low traffic | 245 | BDL | BDL |
| Grader operator (HEPA cab) | 5/24 | Very dry/dusty; low to moderate wind; low traffic | 338 | 0.013 | 0.009 |
| Loader/backhoe (HEPA cab but rear window open) | 5/24 | Very dry/dusty; low to moderate wind; low traffic | 305 | 0.015 | 0.010 |
| SWECO (open cab) | 5/24 | Very dry/dusty; low to moderate wind; low traffic | 343 | BDL | BDL |
| Campground / Restroom Cleaning (dry sweeping pads) | 1/30 | Moderate soil moisture; 50 -60% RH; 45-55° F; moderate wind; low traffic | 275 | 0.041 | 0.024 |
| Campground / Restroom Cleaning | 1/31 | Moderate soil moisture; 50 -60% RH; 45-55° F; moderate wind; low traffic | 262 | 0.014 | 0.017 |
| Transit in Ford F250 | | | 227 | 0.021 | |
| Loader/backhoe (HEPA cab but rear window open) | 1/30 | Moderate soil moisture; 50 -60% RH; 45-55° F; moderate wind; low traffic | 276 | 0.021 | 0.012 |

| | | | | | |
|---|---|---|---|---|---|
| Grader operator (HEPA cab) | 1/30 | Moderate soil moisture; 50 -60% RH; 45-55° F; moderate wind; low traffic | 274 | 0.035 | 0.020 |
| LE Patrol Truck (window down) | 1/31 | Moderate soil moisture; 50 -60% RH; 45-55° F; moderate wind; low traffic | 273 | 0.007 | 0.004 |
| Transit to/from site Dodge PU | | | 213 | BDL | |
| SWECO (open cab) | 1/31 | Moderate soil moisture; 50 -60% RH; 45-55° F; moderate wind; low traffic | 340 | BDL | 0.012 |
| Transit Dodge PU | | | 202 | 0.030 | |

Exposures at the Knoxville site were generally lower than those at Clear Creek and employees spend much less time on-site than in the Clear Creek Area. Public usage also differs. Employee risk levels at Knoxville calculated from the personal monitoring data are an order of magnitude below the risk levels calculated at the Clear Creek site.

## DATA INTERPRETATION

Standard work practices were employed during the sampling period to estimate exposure levels during normal operating conditions. No unusual techniques were used to create unrealistic exposure situations, nor did work practices minimize actual routine exposures during the sampling period.

BLM employee exposures are regulated under the Occupational Safety and Health Administration which established a Permissible Exposure Limit of 0.1 fiber per cubic centimeter using the PCM method of analysis. Historically this PEL has been lowered several times and current literature suggests that this level may not provide adequate protection to employees. With all of the scientific debate on the mechanism of toxicity, definition of asbestos, and definition of the physical characteristics of a fiber, and differing toxicities of the various types of asbestos, the occupational health community still relies on the established exposure limits. The OSHA regulations in 29 CFR 1910.1001 and 29 CFR 1926.58 specify a permissible exposure limit of 0.1 fibers per cubic centimeter of air for an 8-hour time-weighted average exposure. This standard pertains to fibers with a length-to-width ratio of 3 to 1 and a fiber length of greater than 5 μm. An excursion limit of 1.0 fiber per cubic centimeter has also been established by OSHA which limits the exposure during any 30 minute period of the work shift.

**Proposed Risk Assessment Tool**

Exposures at or below the PEL does not imply employees are protected from adverse health effects. Since most risk assumptions follow a linear model, some level of risk still exists at and below the PEL. Tracking the risk level of employees can be a useful tool in managing exposures.

Below is the description of a proposed management tool for BLM to calculate risk levels for employees and determine the number of days an employee may work in the red zone without exceeding the 1 in 10,000 cancer risk level. It utilizes the risk calculation from EPA to be applied to employee exposures. The Unit Risk Factor is based on health outcome studies using PCM exposure data and is relevant to the PCM analytical method used in this survey.

The OSHA PEL is still used for a level not to be exceeded, however the risk calculation can be used to determine the number of days per year an employee can perform a specific job without exceeding a cancer risk of 1:10000. The proposal would use a running arithmetic mean of the exposure data collected for the individual employees. Taking the arithmetic mean of sample measurements is mathematically equivalent to compositing all samples and measuring the concentration of the mixture even though measurements are log-normally distributed. When the number of workdays corresponding to the 1:10000 risk level is exceeded, exposure can be controlled by use of personal protective equipment, or administrative controls to limit time on site. This can serve as a tool for management to control employee exposures using both the OSHA PEL and a cancer risk model.

Excess Lifetime Cancer Risk = EC x URF

Where:

EC = Chronic Exposure Concentration (f/cc averaged over a 70 yr lifetime)
URF = Unit risk factor for inhalation of asbestos $(0.23\ (f/cc)^{-1}$

$$EC = \frac{C_a \times ET \times EF \times ED}{AT}$$

Where:

EC = Chronic Exposure Concentration (f/cc averaged over a 70 yr lifetime)
$C_a$ = Asbestos Concentration in fibers per cubic centimeter (f/cc)
ET = Exposure Time in hours/day
EF = Exposure Frequency in days/year
ED = Exposure Duration in years
AT = Averaging Time of 24 hours/day x 365 days/year x 70 years.

The following equation is used to determine the maximum number of workdays (EF) at the average exposure level for that job ($C_a$) maintaining less than a 1:10000 cancer risk. It is merely solving the above equations for EF using the acceptable excess lifetime cancer risk of 1:10000.

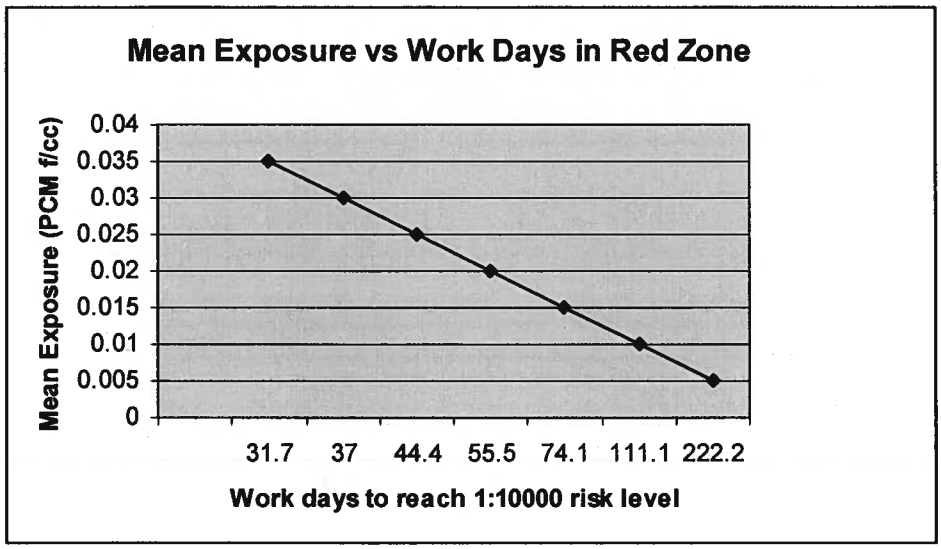
$$EF = \frac{AT \times EC}{(C_a \times ET \times ED)} = \frac{AT \times ELCR}{(C_a \times ET \times ED \times URF)}$$

Where:

ELCR = Excess Lifetime Cancer Risk (selected to be 1/10000)

Proposed employee risk Calculation: Acceptable occupational risk levels generally are greater than those defined by EPA for public risk. For workplace carcinogens, OSHA has not regulated below $1 \times 10^{-3}$, largely because of technical feasibility. The Supreme Court action was instrumental in defining acceptable occupational risk for OSHA. The court suggested that significant occupational risk be determined by comparing the risk in question with other common occupational risks. The court suggested that an occupational lifetime cancer risk of $1 \times 10^{-3}$ is significant when compared to other occupational risks. For the OSHA benzene standard, the maximum estimates of individual risk for benzene are considered tolerable at the $1 \times 10^{-3}$ risk level. On the whole, occupational cancer risk boundaries are understood to be somewhere below $1 \times 10^{-3}$. (Appendix B "Review of Acceptable Cancer Risk Levels, Assessing and Managing Chemical Hazards to Deployed Personnel, US Army 2004). In order to consistently apply risk factors for Clear Creek Management Area, 1 excess cancer in 10000 workers (1:10000) is proposed as an "acceptable risk level" in calculating allowable workdays on site.

For example, an employee with an average measured exposure using PCM of 0.015 fibers/cc an 8-hr time-weighted average will be able to work at the site for 74 days during the year and remain below the cancer risk level of 1:10000. When this risk level is exceeded, protective measures such as use of respirators or use of administrative controls (limiting work to days with optimal environmental conditions) could be implemented to ensure employees are protected and the work is performed.




**Exposure Control Methods**

General Principles of Industrial Hygiene control exposures through a hierarchy of methods. Engineering, work practice, and administrative controls are the primary means of reducing employee exposure to occupational hazards.

Engineering controls minimize employee exposure by either reducing or removing the hazard at the source or isolating the worker from the hazard. Engineering controls include enclosing work processes or confining work operations, and the installation of general and local ventilation systems. This has been accomplished through the use of enclosed cabs, HEPA filtered air in cabs, using back-hoe auger in place of hand digging when possible.

Work practice controls alter the manner in which a task is performed. Some fundamental and easily implemented work practice controls include (1) eliminating dry sweeping, using wet methods where possible, positioning the employee away from the

visible dust where possible, and implementing thorough housekeeping and decontamination procedures.

Administrative controls include controlling employees' exposure by scheduling tasks, in ways that minimize exposure levels. Limit exposure by not working in the contaminated area during extremely dry conditions, and by performing work such as sign installation during very low traffic times.

When engineering controls, work practices, or administrative controls fail to reduce exposures to levels below the acceptable levels, or where they are not feasible to implement, appropriate personal protective equipment such as respirators must be used. Respiratory protection is viewed as the last resort in the hierarchy of control measures.

**RECOMMENDATIONS:**

**Clear Creek**

- Employee exposures can be controlled through administrative controls such as limiting work in contaminated area during extremely dry condition. For tasks that cannot be avoided or rescheduled, employees should wear respiratory protection. Use respiratory protection during potentially high exposure tasks such as performing mechanical repairs on SWECO or heavy equipment where heavy dust accumulation.
- Continue with employee exposure monitoring using PCM analytical methods.
- Continue with medical surveillance.
- Continue with respiratory protection program and ensure proper use of PPE whenever exposure conditions warrant.
- Restructure the decontamination facility and ensure thorough decon procedures are followed.
- HEPA vacuum the SWECO cab after each work shift.
- Evaluate the risk calculator for employee exposures. Use mean of exposure measurements for each employee as input into risk calculator to monitor employee risk level and allowable red zone work days.

**Knoxville**

- Eliminate dry sweeping of camping pads and restrooms.

- Routinely HEPA vacuum vehicles used to transport employees to and from the worksite.
- Routinely HEPA vacuum heavy equipment cabs.
- Repeat employee exposure monitoring if work frequency or conditions change.