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SCREENING LEVEL EVALUATION OF POTENTIAL HUMAN HEALTH RISKS FROM EXPOSURE TO ASBESTOS AT THE NORTHWEST NEIGHBORHOOD OF THE FORMER LOWRY AIR FORCE BASE

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EXECUTIVE SUMMARY

Asbestos-containing waste, containing up to 84% asbestos (i.e., chrysotile, crocidolite, amosite, and tremolite), has been discovered throughout the Northwest Neighborhood (NWN) at the former Lowry Air Force Base (Lowry), both on the surface of the ground and in the subsurface. Over 100 homes have already been constructed and occupied and approximately 200 additional lots are under or available for construction.

This document provides the Department's Risk Screening Analysis related to potential asbestos exposures in the Lowry NWN. The Department used this information and other data as support for the risk management decisions (i.e., cleanup actions) implemented in the NWN. The analysis concludes that there is a need to eliminate and/or minimize exposure to asbestos-containing waste and soils contaminated with asbestos fibers for the following reasons:

a. Even small amounts of asbestos in soil (0.001%) can generate hazardous levels of airborne asbestos fibers higher than 0.1 f/cc (i.e., OSHA limits).

b. National and international health agencies have classified asbestos as a known human carcinogen. Scientists agree that exposure to any type (i.e., serpentine or amphibole) can increase the risk of lung cancer, mesothelioma, and other nonmalignant respiratory effects.

c. There are numerous reasonably expected mechanisms that can release and transport asbestos in the environment with the potential to expose residents to asbestos at levels of concern. Accordingly, measures are needed to minimize and/or eliminate the potential

pathways of exposure to asbestos-containing debris and asbestos fibers in surface and subsurface soils.

d. A risk screening analysis demonstrates that common expected activities by residents, such as digging in asbestos contaminated soils, pose an unacceptable risk to public health. This analysis does not evaluate potential exposure to asbestos as a result of tracking asbestos contaminated soils into homes, which could substantially increase the cumulative risk.

This evaluation strongly supports the need to manage the risk posed by potential exposure of residents of the Northwest Neighborhood to asbestos.

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SCREENING RISK EVALUATION OF POTENTIAL HUMAN HEALTH RISKS FROM EXPOSURE TO ASBESTOS AT THE NORTHWEST NEIGHBORHOOD OF THE FORMER LOWRY AIR FORCE BASE

I. INTRODUCTION

This document presents an overview of information from the scientific literature on the analysis of potential exposures and associated asbestos-related health risks. EPA generally recommends a tiered framework for risk assessment. Balancing the need for accuracy with considerations of cost and timeliness, this could include an initial conservative screening analysis; a refined or simple site-specific screening approach; and a detailed site-specific monitoring and/or modeling approach for more comprehensive consideration of site-specific conditions (e.g., EPA, 1994; 1996; 1998; 2000). This document comprises the first tier only; namely, a risk screening analysis. Asbestos has been found on and adjacent to the Northwest Neighborhood (NWN) of Lowry. The NWN is a residential community currently undergoing extensive development. The Department considered these facts and reviewed existing laboratory and other site-specific asbestos studies as part of this risk screening.

II. BACKGROUND ON SITE AND HEALTH RISK CHARACTERIZATION

The Lowry Redevelopment Authority (LRA) and various developers are currently developing portions of Lowry into a residential community. This includes the NWN, approximately four hundred lots located between north of 8th Avenue, south of 11th Avenue, west of Uinta Way and east of Quebec Street.

Beginning in April 2003, asbestos-containing waste was discovered at several locations, both on the ground surface and in the subsurface, in the NWN. The asbestos-containing debris appears to be associated with a complex of US Air Force buildings that were demolished in place between 1959 and 1979. The asbestos-containing debris consists mainly of old, discarded water pipes, steam pipes, and insulation material.

The locations where such debris has been found include lots with occupied homes, lots under construction and lots where no construction has begun. Thus, the potential hazard, due to asbestos-containing debris and asbestos fibers in surface and subsurface soils, to current and future residents needs to be evaluated and, if necessary, mitigated.

A determination of the potential future health risks to residents from exposure to the four types of asbestos (i.e., chrysotile, crocidolite, tremolite, and amosite) found at Lowry is challenging because of uncertainties associated with: (a) the methods used to analyze asbestos; (b) the estimation of potential exposure to airborne asbestos from contaminated soils; and (c) the toxicological information, especially, mechanisms of asbestos toxicity. Therefore, the potential for human health risk from exposure to asbestos-contaminated soils is evaluated qualitatively and/or semi-quantitatively by considering the following evidence:

1. The existing knowledge regarding asbestos contamination and the associated health effects; and
2. Risk estimates based on a risk screening analysis.

1. ASBESTOS AND ITS HEALTH EFFECTS: OVERVIEW

The major sources for the following information concerning asbestos and its health effects include reviews by ATSDR (2001, 2003a,b); and EPA IRIS (2003).

1.1. Asbestos

The following characteristics of asbestos reflect the unique complexity associated with the nature of asbestos and have relevance to human health risk characterization.

- Asbestos is a generic term used to describe a group of fibrous silicate minerals that occur naturally in the environment, and have been used commercially. The most widely accepted definition of asbestos includes the fibrous varieties of six minerals. Asbestos falls into two groups, serpentine and amphibole. The most common type of asbestos is chrysotile, which is serpentine. The other five asbestos minerals are amphiboles, and include the minerals amosite, crocidolite, tremolite, anthophyllite, and actinolite.
- The general chemical composition of serpentine asbestos is reported as magnesium silicate. Serpentine asbestos possesses relatively long, curved, and flexible crystalline fibers that tend to form a tubular structure. Amphiboles (e.g., crocidolite) are generally ferro-magnesium silicates and have rod- or needle-shaped brittle fibers.
- Historically, regulatory agencies such as the Occupational Safety and Health Administration (OSHA) and EPA define an asbestos fiber as a particle with a length >5um and aspect ratio (length-width ratio) >3:1. It should be noted that EPA defines a fiber as any particle with aspect ratio >5:1 when analyzing bulk samples for fiber content. This regulatory definition of a fiber, based on recent evidence, does not appear to be consistent with the biological activity of asbestos structures. Asbestos fibers can fracture or split and break into smaller diameter fibrils. A single fiber can split into hundreds of fibrils.
- Asbestos dust is a complex mixture of fibrous structures. Not only do single fibers vary in dimensions but also such fibers may be found combined with other fibers in the form of bundles, clusters, or matrices. These are known as asbestos structures that can be inhaled.

- Asbestos fibers are basically chemically inert. They do not evaporate, dissolve, burn, or biodegrade in the environment. However, single fibers and clumps of fibers may be released in the air as dust as a result of wind erosion and other types of activities that generate dust.

1.2. Potential for human exposure to release of asbestos fibers from asbestos-containing waste

It is well known that asbestos exposure and health effects are related to asbestos fibers in air that are released from asbestos materials during natural and anthropogenic activities. The following evidence demonstrates that asbestos-containing waste (even with 0.001% asbestos) can release hazardous levels of airborne asbestos fibers if disturbed by human and/or natural activities. The Department recognizes that available evidence cannot be fully translated to the NWN at Lowry. As an example, the Libby, Montana asbestos containing vermiculite soils have not been found in the NWN of Lowry. Even so, Addison et al (1988) have shown that irrespective of the type of asbestos fiber, high airborne fiber concentrations can be generated from less than 1% asbestos in soil. Moreover, the EPA studies at Libby are some of the most recent and compelling studies regarding the ability of asbestos fibers to be released from soil matrices during routine residential activities.

1. <u>Evidence of asbestos release based on the Libby site-specific studies (EPA, July and December 2001; Weis memo):</u>

   a. Release of asbestos fibers, from soil containing <1% to 6% asbestos, during removal activities by workers at the Screening Plant (Table 2; EPA, July, 2001):

      - It was demonstrated that concentrations significantly above the OSHA occupational limit of 0.1 f/cc were detected by personal air monitors in the breathing zone of workers, during routine activities including soil bagging and sweeping floors for most size classes as measured by TEM analysis. (OSHA's occupational provisions do not apply to residents of Lowry). For example, the concentrations were:

        < 0.61 f/cc for fibers of length = 0.5 to 5 um; diameter <0.5 um
        3.055 f/cc for fibers of length = 5-10 um; diameter <0.5 um
        1.222 f/cc for fibers of length > 10um; diameter <0.5 um
        1.222 f/cc for fibers of diameter >0.5um

        These initial findings prompted more studies which resulted in the maximum concentration of 1.72 PCM f/cc.

   b. Release of asbestos fibers, from soil containing < 1% to 5% asbestos, from locations along Rainy Creek Road (Table 4; EPA, July, 2001):

- As a result of disturbance by vehicular traffic, the levels of asbestos fibers in air were clearly elevated in stationary monitors, up to a maximum of 0.0116 TEM f/cc (diameter < 0.5; length = 0.5 –5 um).

c. Indoor release of asbestos fibers, from materials containing <1% to 10% asbestos as a result of routine activities performed by residents:

- Phase 1 results- Elevated levels of asbestos fibers were observed in the breathing zone of residents by personal monitors during the following activities (Table 3; EPA, July, 2001):
  Routine activity = 0.001 PCME-asbestos f/cc;
  Active cleaning = 0.033 TEM PCME f/cc;
  Simulated remodeling = 0.557 PCME-asbestos f/cc.

  (Please note that "PCME-asbestos" represents "PCM equivalent" of TEM measurements).

- Phase 2 results - Elevated levels of asbestos fibers were observed in the breathing zone of residents by personal monitors during the following activities (Table 6; EPA, December, 2001):
  Routine activities = 0.023 – 0.048 PCME-asbestos f/cc;
  Active cleaning = 0.004 – 0.013 PCME-asbestos f/cc.

d. Outdoor release of asbestos fibers, from garden soils containing <1% asbestos, during rototilling by residents:

- Exposure of an individual engaged in rototilling a garden in Libby was monitored. Elevated levels of asbestos fibers were observed in both personal monitor (0.066 PCME-asbestos f/cc) and stationary monitor (0.019 PCME-asbestos f/cc) (Table 5; EPA, December, 2001). Release of asbestos from vermiculite containing less than 1% asbestos (Table 7; EPA, December, 2001):

- Elevated levels of asbestos fibers were observed in personal monitors of people engaged in vermiculite disturbance activities in unfinished attic areas. In fact, active disturbance resulted in very high concentrations of 0.042-1.057 PCME-asbestos f/cc. According to EPA (2001), these findings are consistent with studies conducted by W.R. Grace noted below.

2. W.R.Grace (as cited by EPA, December, 2001) studies with vermiculite containing < 1% asbestos:

   "These studies demonstrated that fiber concentrations in air resulting from pouring vermiculite insulation onto floor under controlled conditions can be extremely high even when bulk concentration in the vermiculite are less than 1% (Grace, 1976)." (p. 11; EPA, December 2001).

3. NIOSH (2003) recommendation demonstrating release of asbestos from vermiculite containing <1% asbestos:

   A recent publication of the National Institute of Occupational Health and Safety (NIOSH) publication states, "Disturbing contaminated vermiculite with less than 1% asbestos can still result in hazardous concentrations of airborne asbestos fibers."

4. Addison et al. (1988) study demonstrated release of asbestos fibers (>OSHA occupational limit of 0.1 f/mL) from soils containing 0.001% asbestos:

   Addison et al. (1988) conclude by stating, " Mixtures of asbestos in dry soils with asbestos content as low as 0.001% can produce airborne respirable asbestos concentrations greater than 0.1 f ml^{-1} in dust clouds where the respirable dust concentrations are less than 5 mg m^{-3}." (p. 21).

5. EPA has officially stated that soils containing <1% asbestos could present health risks (EPA, 2001):

   A recent EPA Region 8 fact sheet states, "Levels of 1% or less could present a risk where there is enough activity to stir up soil and cause asbestos fibers to become airborne."

6. According to ATSDR (2003a), EPA is planning removal of trace levels of asbestos at the former Western Mineral Denver Plant at South Navajo Street, Denver:

   A recent draft Public Health Consultation report (ATSDR, 2003a) states, " EPA is planning removal of soil from locations around the site which have trace levels of tremolite-actinolite asbestos or higher. This action will be protective of public health for current and future exposures." (personal communication, Joyce Ackerman, US Environmental Protection Agency, August 2003)

1.3. Health effects of asbestos

The health effects of asbestos exposure have been previously reviewed extensively (ATSDR 2000, 2001, 2003b; EPA IRIS; Churg and Wright, 1994; and Stayner et al.1996, 1997) and a brief summary is provided below.

It is known that inhalation of asbestos fibers suspended in air can result in lung cancer, malignant mesothelioma, and nonmalignant respiratory effects including pulmonary interstitial fibrosis (*asbestosis*); localized or diffuse areas of thickening of the pleura (*pleural plaques*); extensive thickening of the pleura (*pleural thickening*); pleural calcification; and fluid buildup in pleural space (*pleural effusions*). These findings are in agreement with results from mechanistic studies as well as studies of animals exposed by multiple routes. The risk of developing any one of these diseases depends upon many factors including the chemistry of fibers, shape and size of fibers, exposure level and duration, the individual's susceptibility, and the smoking history of the exposed individual. According to ATSDR, (2001), these diseases have been observed in workers exposed to a cumulative dose ranging from about 5 to 1200 f-year/mL. The cumulative dose of 5 f-year/mL, for example, can result from 40 years of low-level exposure to 0.125 f/mL or 10 years of higher-level exposure to 0.5 f/mL.

Despite the debate in the scientific literature concerning the relative toxic potential of different types of asbestos, there is general agreement among the scientific community on the following issues regarding the health effects of asbestos.

a. National and international health agencies have classified asbestos as a known human carcinogen.
b. Exposure to any type of asbestos (i.e., serpentine or amphibole) can increase the risk of lung cancer, mesothelioma, and nonmalignant lung and pleural diseases.
c. Important determinants of toxicity include cumulative dose (exposure duration x exposure concentration), fiber dimension, and durability.
d. The combination of tobacco smoking and asbestos exposure synergistically increases the risk of developing lung cancer.
e. Asbestos-related diseases can occur as a result of either heavy exposure for a short time or lower exposure over a longer period of time. For example, some cases of asbestosis have occurred as a result of 1-day intense exposure (ATSDR, 2000).
f. Most cases of asbestos-related disease occur after 15 or more years. In general, latency periods are10-40 years.

2. RISK SCREENING ANALYSIS FOR FUTURE POTENTIAL ASBESTOS EXPOSURE

2.1. Overview of EPA's risk assessment process

The primary purpose of risk assessment is to provide risk managers with an understanding of the current and future risks to human health posed by the site and any uncertainties associated with the assessment. Specifically, the 1990 National Contingency Plan (NCP) (55 Fed. Reg. 8665-8865 (Mar. 8, 1990) states that the risk assessment should " characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to ground water or surface water, releasing to air, leaching through soil, remaining in the soil…." (Section 300.430(d) (4) as cited by EPA, 1991a OSWER DIRECTIVE 9355.0-30). Risk assessment is generally a four-step process consisting of hazard identification, exposure assessment, dose-response assessment, and characterization of risk based on the combination of results of the three previous steps, and the associated uncertainties (EPA, 1989, RAGs Part A; EPA, 1992a).

Traditionally, EPA recommends a tiered framework for risk assessment. The three-tiered framework could include an initial conservative screening analysis; a refined or simple site-specific screening approach; and a detailed site-specific modeling approach for more comprehensive consideration of site-specific conditions (e.g., EPA, 1994; 1996; 1998; 2000). The decision regarding which of the three approaches is most appropriate for a given site must balance the need for accuracy with considerations of cost and timeliness (EPA, 1996). It is important to note that risk assessment only provides one of several important tools in the whole risk management process. EPA's regulatory process also calls for consideration of non-scientific factors (e.g., economic, social, political, and legal factors) in decision-making (EPA, 1992a). In this case, the Department has conducted a risk screening analysis.

2.1.1. Objective and Scope of the Human Health Risk Screening Analysis

Given the above noted information regarding the generation of hazardous levels of airborne asbestos fibers from materials containing < 1% asbestos (e.g., Addison, 1988; EPA's Weis Memo, December 2001), it is reasonable to assume that exposure to soils, even with < 1% asbestos could result in unacceptable health risks. Thus, the emphasis of this screening analysis is to assist in reviewing the potential remedies that are adequate to mitigate the unacceptable health risks by evaluating the following: (1) whether unacceptable risks could occur due to common soil intrusive activities such as digging in soils contaminated with asbestos; and (2) if unacceptable exposure and risk could occur, which potential remedies are adequate to minimize the unacceptable health risks.

In accordance with the above objectives, this risk screening analysis is scoped as follows:

1. The major focus is to evaluate risks for exposure to <1% asbestos-contaminated soil as a result of out-door activities. It is, however, important to note that risks due to exposure to 1% asbestos-contaminated soils are addressed only when allowed by the available data for certain exposure scenarios. It is also important to note that actual concentrations of asbestos in soils within the NWN are unknown due to the compositing of up to ten soil aliquots into individual samples as described elsewhere.
2. It is assumed that remedial actions such as application of a sod cover are available to attempt to eliminate/minimize the current/future exposure pathways. However, a sod cover may not ensure adequate public health protection under a variety of exposure scenarios which can result in the disturbance of soils and completed exposure pathways; for example, in areas such as flower beds and vegetable gardens. Moreover, excavated soils brought inside homes by children, pets, and through contaminated clothing and shoes could act as a potential future source of release of asbestos fibers in air.
3. This risk screening analysis does not evaluate risks, quantitatively, due to indoor air exposure to asbestos fibers (i.e., asbestos-containing debris and soil brought indoors). This exposure pathway will be discussed qualitatively as a part of the uncertainty analysis.

2.2. Risk Screening Analysis to Estimate Future Potential Risks

This risk screening analysis is briefly discussed in accordance with the steps of EPA's risk assessment process: (1) hazard identification; (2) exposure assessment; (3) toxicity assessment; and (4) risk characterization and uncertainty analysis.

2.2.1. Hazard Identification

The potential hazard is that asbestos-containing friable debris and asbestos fibers are present in surface and subsurface soils in the NWN of Lowry. It should be noted that asbestos fibers in soil or dust do not inherently pose a risk to human health if left undisturbed. Therefore, health risks from asbestos-containing debris and fibers in soil will depend on the potential for asbestos fibers to become airborne and be inhaled. The asbestos containing waste material that is readily accessible in the NWN is vulnerable to disturbance by various anthropogenic or natural activities. Consequently, current and future residents can be potentially exposed to asbestos fibers released from asbestos-containing debris or soil due to disturbance by common human intrusive activities or natural processes (e.g., wind erosion, precipitation, and extreme changes in temperature) either now or in the future.

Asbestos is known to be persistent in the environment. Furthermore, the continued degradation of asbestos-containing debris would act as a continuous source of asbestos fibers in surface and subsurface soils that may become airborne when the soils are disturbed in the future. It should be noted that these soils can act as a reservoir of loose asbestos fibers that could continue to be released to the air. Moreover, asbestos fibers can be tracked into homes through residents and pets, where they can create an on-going source of exposure by being re-entrained as a result of routine activities inside the home. Also, children can bring asbestos-containing debris and soils inside home in toys for playing activities.

There is no significant migration of asbestos fibers from the soil, except from disturbance by human or natural activities. It is, however, important to note that uncontrolled drainage of water from asbestos-contaminated areas may result in environmental dispersion of asbestos.

2.2.1.1. Overview of the extent of asbestos contamination at the Lowry Air Force Base

As of July 30, 2003, the following initial information was available regarding the extent of asbestos contamination in the NWN of Lowry:

- Type of asbestos in debris and soil – Predominantly serpentine type of asbestos (e.g., chrysotile); about three to five percent (3-5%) of samples contain amphibole type of asbestos (e.g., crocidolite and amosite)
- Asbestos-containing debris – May contain up to eighty-four percent (84%) of asbestos. As of July 30, 2003, asbestos-containing debris has been found both on the surface and in the subsurface soil of approximately thirty (30) lots in the NWN.

- Indoor data (air and dust samples) – As of July 30, 2003, indoor sampling has been performed in about ninety-six (96) homes, and current data show that there is no evidence of indoor asbestos contamination under controlled conditions. The possibility exists that this could be due in part to the fact that the homes are new and have been cleaned, yards have been covered in hay and residents have exercised caution in keeping windows and doors closed.
- Surface soil (0-1 inch depth interval) contamination by asbestos fibers – As of July 30, 2003, an average of twenty (20) surface soil samples were collected from each residential lot. Surface soil samples have been taken on one hundred eighteen (118) lots. Initial results indicate that roughly one-third show detections of asbestos fibers (< 1%) on at least some portion of the lot.
- Subsurface soil (1 inch to > 2 feet depth interval) contamination by asbestos fibers -As of July 30, 2003, an average of sixty-five (65) subsurface soil samples were collected from each residential lot. Subsurface soil samples have been taken from one hundred eleven (111) lots. Initial results indicate approximately two-thirds show detections of asbestos fibers (< 1% to > 1%) on some portion of the lot.

Approximately seventy-six (76) lots show, through composite sampling, the presence of a detectable level of asbestos samples containing <1% to >1% asbestos in either surface or subsurface soils. This ranges from an isolated detection to numerous grids containing asbestos fibers (each lot was divided into sampling grids of approximately 200 square feet in size).

2.2.2. Exposure Assessment

The US EPA guidelines for exposure assessment (EPA, 1992b) establish a broad framework for conducting exposure assessments. The goal of the human exposure assessment is to estimate the magnitude of exposure to asbestos by human population. The exposure assessment is addressed here by discussing the following:

(1) A conceptual site model: (i) the source; (ii) the mechanisms of release and transport; (iii) the affected media; (iv) the characterization of potential land uses; (v) identification of current and future potentially exposed populations; and (vi) identification of exposure pathways;

(2) Estimation of exposure point concentration; and

(3) Estimation of human exposure dose.

2.2.2.1. Conceptual site model

A conceptual site model is illustrated in Figure 1 and is discussed below.

1. Source of exposure – There are three sources of exposure: (1) Asbestos-containing debris in surface and subsurface soils; (2) Free asbestos fibers in surface and subsurface soils;

and (3) Indoor sources including settled dust, asbestos-containing debris and contaminated soil brought inside the home, and infiltration from outdoor air.

2. Mechanisms of asbestos release and transport – Asbestos may be released from each source by disturbance due to human activities and/or by natural processes. These are briefly described below:

(a) Examples of common intrusive activities performed by residents:

- Rototilling of soils in flower and vegetable gardens.
- Rototilling for installing new landscaping when the existing lawn is dead (partially or completely).
- Digging holes for planting trees and bushes.
- Disturbance of the grass-covered yard soil from activities such as weeding, mowing the grass, aerating, and habitual digging by pets and wild animals.
- Disturbances of sparsely vegetated areas of yard by walking, playing, biking, mowing, etc.
- Management of excavated soils by bagging and floor sweeping.
- Disturbance by children of exposed soils that exist under swing sets and other play equipment.
- Disturbance during physical handling of asbestos-containing debris and contaminated soils as might occur if children play with the materials.

(b) Examples of natural processes that may result in release of fibers from asbestos-containing debris and/or soils:

- Forces exerted by wind currents on existing free asbestos fibers in soil at the surface or excavated soils due to the above activities.
- Forces exerted on asbestos-containing debris by shifting soils due to extreme changes in temperature, precipitation, or other natural processes.
- Re-suspension of settled dust when residents perform routine household activities.

(c) Examples of activities that may result in large amounts of excavated soils and a resultant on-going source of asbestos release in air:

- Planting trees or bushes.
- Excavating dead trees and bushes.
- Outdoor minor construction such as installing an in-ground hot tub, play equipment, a deck, patio fences or other structures.
- Installing or repairing sprinkler system.
- Installing decorative pathways by flagstones on the grass-covered yard.

(d) Examples of mechanisms by which asbestos may be transported outdoors or indoors:

- Wind transport through open doors and windows.

- Track-in of adhered fibers on clothing and shoes of children as well as adults, and through pet animals.
- Children physically carrying asbestos-containing soil and debris in toys inside home for playing.

3. Affected media – Potentially affected media include soils and air. However, this risk screening analysis only evaluates the risk associated with air borne asbestos fibers because undisturbed asbestos in soil generally does not pose a risk to human health. Additionally, the ingestion of soils is not considered the potential exposure pathway of major concern because of the association of much lower potential health risks with ingested asbestos than with inhaled asbestos (ATSDR, 2001). Thus, by addressing the substantial risks associated with the inhalation of asbestos fibers in air, the public health should be adequately protected.

4. Current and future land use – Currently, the NWN land use is primarily residential. A Day Care Center and two parks are also located within the NWN. It is assumed that the NWN will remain as residential use, with limited recreational and commercial/industrial land use.

5. Identification of current and future potentially exposed populations – The identification of potentially exposed populations (or human receptors) is based on the consideration of current and anticipated land uses. Therefore, the current and potential human receptors included in this screening analysis are adult and child residents performing routine indoor and outdoor activities.

6. Potential exposure pathway – EPA (1989) defines an exposure pathway as the course a chemical or a physical agent takes from the contaminant source to the exposed individual. A complete exposure pathway includes a source, release mechanism, transport mechanism, an exposure medium (e.g., air in this case), an exposure point, and a receptor. Therefore, inhalation of airborne asbestos fibers is considered the primary route of exposure because air represents a primary medium for asbestos transport and exposure.

2.2.2.2. Exposure point concentration

The concentration of asbestos in soil and air to which an individual could be exposed is called the exposure point concentration. It is, however, important to emphasize that the relationship between soil and air levels of asbestos fibers is complex, and the generation of airborne fibers is not predominantly dependent on the type of asbestos. The potential for asbestos fibers to become airborne depends on the type and state of matrix in which it is present, as well as the potential for mechanical disruption of the matrix by human and/or natural activities. Therefore, air or soil sampling data for asbestos contamination represents only a snapshot in time that generally will not be a good representative of exposure under various complex activities and environmental conditions. Therefore, qualitative or semi-quantitative assessment of the distribution of the asbestos-containing waste and potential for asbestos fibers to become airborne remains the important aspect of exposure assessment, and is applied in this risk screening analysis. The estimation of asbestos concentration in soil and air, based on extrapolation from other asbestos studies, is briefly discussed below.

1. Exposure point concentration for asbestos fibers in soil

   The intended use of the risk screening analysis usually defines the scope of exposure assessment or approaches used to estimate exposure (EPA, 1992b). For instance, in this case, as previously discussed, there are studies that show that the presence of any amount of asbestos fibers in soil (even up to 0.001%) can generate unacceptable levels of asbestos fibers in air, if disturbed by human activities or natural processes. Therefore, the objective of the soil sampling program in the NWN of Lowry was to determine the presence or absence of asbestos fibers in soil. Thus, the measurement of concentration of asbestos fibers in soil 2. was based on composite sampling (i.e., soil samples were collected from different locations and mixed together). This method provides a potentially diluted concentration of asbestos fibers in soil. It should be noted that the sampling plan in the NWN of Lowry does not facilitate the identification of asbestos hot spots. Yet, current data shows that the concentration of asbestos fibers in soil varies from < 1% to > 1%.

2. Exposure point concentration for asbestos fibers in air

   According to EPA's exposure assessment framework (EPA, 1992b), a variety of approaches can be used to estimate exposure point concentration. These range from quick screening level methods of using the existing data or models to more sophisticated techniques of collecting new data. To estimate the exposure point concentration of asbestos fibers in air, the point of contact approach may be used. This approach involves measurement of asbestos fibers at the point where they contact the exposed individuals (i.e., breathing zone), usually by using personal monitors, during the various types of activities routinely performed by child and adult residents, and a record of the exposure time of contact during each type activity. Sometimes, for an inhalation exposure assessment, point of contact approach is combined with emission and dispersion models that are appropriate for the scenario specific circumstances under which such exposure is expected to occur. The available emission and dispersion models for dust particles, however, are not designed for modeling of asbestos concentrations in soil to predict concentrations of asbestos fibers in air. Several dust generation models with a series of adjustments are being considered for asbestos modeling (e.g., Berman, 2000). However, the use of these models is premature and would add additional uncertainty in the prediction of airborne asbestos concentrations, because it is complex to model the releasable form of asbestos in the bulk form and then to model asbestos suspension and movement in air. Traditionally, point of contact data can be collected by: (a) conducting new exposure monitoring while individuals actually perform various activities; (b) conducting new simulation studies; and/or (c) using existing monitoring data from other studies.

In accordance with EPA's exposure assessment framework (EPA, 1992b), existing point of contact monitoring data from other studies can be used. However, "the assessor must consider the factors that existed in the original study and that influenced the exposure levels measured. Some of these factors are proximity to source, activities of the studied individuals, time of day, seasons, and weather conditions." (EPA, 1992b; p. 22909). In this assessment, the use of point of contact data from EPA's Region 8 Libby, Montana study (EPA, December 2001, Weis Memo) was considered. The Department, however, recognizes that these results cannot be fully extrapolated to the Lowry situation. For example, there are certain site-specific differences between the Libby and Lowry sites, especially, in terms of asbestos type and source. Therefore, as an additional check, experimental data from Addison et al. (1988), based on chrysotile asbestos in soil, is used to illustrate the impact of differences in asbestos type and source. A brief summary of the relevant data is provided below:

a. <u>Estimation of exposure point concentration from exposure to soil (containing < 1% asbestos) related to rototilling type of activities is provided below:</u>

- Limited information is available on the potential release of asbestos fibers as a result of mechanical disturbance of garden soils during various activities listed above. For example, EPA's Phase 2 study (as cited by EPA, Dec. 2001; Weis memo) demonstrated elevated levels of fibers in both personal air samples (mean concentration of 0.066 PCME-asbestos f/cc by TEM) and in nearby stationary monitors (mean concentration of 0.019 PCME-asbestos f/cc by TEM) during rototilling activities.
- Based on the above data, the concentration of 0.066 f/cc will be used in this analysis to calculate lifetime excess cancer risk from exposure during rototilling and other similar soil-intrusive activities, and the mean concentration of 0.019 f/cc in nearby stationary monitors will be used for other type of activities with a lower potential of mechanical disturbance.

b. <u>Estimation of exposure point concentration from exposure to soil (containing up to 1% asbestos) based on experimental studies of Addison et al. (1988):</u>

- Addison et al. (1988) generated airborne dust clouds from mixtures of soils with different asbestos varieties in bulk concentrations ranging from 1.0 to 0.001 % of chrysotile, crocidolite, and amosite. The dust concentrations were maintained at around 5 mg/m^3, the occupational exposure limit for a dust, for about 4 hours in a $1.3m^3$ test chamber. A flow of air of between 10 and 40 liters per minute, depending on soil type, was passed into the chamber and the airborne fiber concentrations were measured throughout. The results of phase contrast optical microscopy (PCOM) were also confirmed by scanning electron microscopy (SEM). In summary, "the average respirable fibre concentrations by PCOM for all soil and all asbestos types were highest for the 1% mixtures at 10.8 f ml^{-1} and were progressively lower for each of the lower concentration mixtures in turn, with 0.11 f ml^{-1} found for the 0.001% mixtures." (Addison et al., 1988, p. 10).

Examples of data for average airborne respirable fibers specific to soil and asbestos types are noted below.

Examples of data for SEM vs. PCOM based on the dust concentration of 5mg/m^3 (Table 3.6 of Addison et al., 1988):

Chrysotile 0.001% in intermediate soil = 0.23 f/mL by SEM; 0.08 f/mL by PCOM

Chrysotile 0.1 % in clay = 1.17 f/mL by SEM; 0.42 f/mL by PCOM

Chrysotile 1% in intermediate soil = 48.5 f/mL by SEM; 5.76 f/mL by PCOM

Crocidolite 0.1 % in clay = 2.75 f/mL by SEM; 1.12 f/mL by PCOM

Examples of data by PCOM normalized to the dust concentration of 1mg/m^3 (Table 3.1 of Addison et al., 1988):

Chrysotile 0.1% in intermediate soil = 0.06 f/mL/mg m^{-3} of dust concentration

Chrysotile 1.0% in intermediate soil = 1.74 f/mL/mg m^{-3} of dust concentration

Crocidolite 0.1% in intermediate soil= 0.27 f/mL/mg m^{-3} of dust concentration

Crocidolite 1.0% in intermediate soil= 2.9 f/mL/mg m^{-3} of dust concentration.

- Based on the above data, an airborne concentration in a range of 0.06 to 1.74 f/mL/mg m^{-3} of dust concentration, as a representative of soils containing 0.1% to 1.0 % of chrysotile asbestos, will be used for activities resulting in the generation of higher amounts of dust. For example, bagging of excavated soils by adults and children playing in piles of excavated soils.

2.2.2.3. Estimation of human exposure dose

The final step of the exposure assessment is to quantify the pathway specific intake dose for the identified receptor population by integrating the exposure point concentration with exposure and intake parameters (e.g., frequency and exposure of duration, and inhalation rate). The use of these exposure parameters is briefly discussed below.

1. Exposure parameters

   According to EPA guidance (EPA, 1989, 1992b) intake and exposure variable values for a given exposure pathway are selected so that the combination of all intake variables result in an estimate of dose of the “reasonable maximum exposure” (RME), which is defined as the maximum exposure that is reasonably expected to occur at a site. Conceptually, the RME describes exposures above the 90^{th} percentile of the population distribution, i.e., 90th to 95th percentile (EPA RAGs, 1989). The quantitative information on exposure/intake parameters is generally based on EPA's default values. It is, however, important to emphasize that a determination of reasonable exposure cannot be based solely on EPA's quantitative information or default values, but also requires the use of professional judgment. Accordingly, the following exposure parameters for various scenario specific activities are based on a combination of EPA's recommendations (EPA 1991b OSWER Directive), information from other sites, and professional judgment.

a. Default exposure parameters for a residential scenario:

Exposure duration for a resident = 30 years (EPA, 1991b)
Exposure duration for a child resident = 6 years (EPA, 1991b)
Averaging time for carcinogens = 70 years (EPA, 1991b)

b. Scenario/activity-specific exposure parameters for adults and children:

- Gardening/yard activities for Adults:

  According to EPA's Exposure Factor Handbook (EPA, 1997; Volume III), no data specific to gardening times and frequencies could be found; thus, no firm recommendations are made by EPA. However, EPA (1997) provides three sets of indirect data for consideration in deriving time estimates for gardening. These data indicate time spent in the garden or other circumstances working with soil for persons 18-64 years old for the 90th, 95th, and 99th percentile at 16, 40, and 200 hours/month, respectively. However, EPA (1997; Vol. III, p. 15-16) recommends an upper percentile of 40 hours/month for adults. This information is combined with professional judgment, and data from other site-specific assessments to select the following:

  Rototilling activity = 2 hr/day; 8 days/year (adopted from EPA, December 2001 Weis memo).

  Other soil-intrusive activities listed above (e.g., planting trees/bushes, vegetables, and flowers, weeding, excavating dead bushes/trees etc.) = 2hr/day; 20 days/year.

  Management of excavated soils (e.g., bagging soil, and sweeping floor) = 1hr/day; 8 days/year.

- Recreational activities for Children:

  According to EPA (1997), activities can vary significantly with differences in age. Therefore, special attention should be given to the activities of populations under the age of 12 years. Based on the EPA recommended study, outdoor activities for children (ages 3-11 years) accounted for 5 hrs/day for weekdays and 7 hrs/day on weekends. Also, site-specific risk assessment for the Rocky Mountain Arsenal (RMA, Record of Decision, 1996) used 8hrs/day for 108 days/year for outdoor recreational activities by children. Based on this information, the following assumptions are used in this risk screening analysis:

> Time spent on play-equipment (swings, slides, etc.) = 1 hr/day; 80 days/year
> Time spent playing with excavated soils or helping parents in bagging soil = 1hr/day; 15 days/year.

2.2.3. Toxicity Assessment

The objective of the toxicity assessment is to evaluate the available evidence regarding the toxic potential of asbestos and to provide, where possible, an estimate of the relationship between dose and the increased likelihood and/or severity of adverse health effects. EPA has not yet derived any noncancer toxicity value for asbestos.

EPA has classified asbestos as a known human carcinogen and provided an inhalation unit risk factor of 0.23 per PCM f/cc in IRIS (EPA, 2003) (that is, the cancer risk per asbestos fiber per cc of air inhaled over a lifetime). This value estimates additive risk of lung cancer and mesothelioma using a relative risk model for lung cancer and an absolute risk model for mesothelioma. This means that the mesothelioma risk model is independent of the background risk, which is considered to be negligible in the general population. The mesothelioma model also assumes that risk increases exponentially with time after a 10-year lag period. Since a relative risk model is used for lung cancer, the absolute risk for lung cancer due to asbestos exposure depends not only on cumulative dose for asbestos, but also on the underlying risk for lung cancer due to other causes.

2.2.4. Risk Characterization

The general approach used in this risk screening analysis for risk characterization is based on EPA's framework (EPA RAGs, 1989, and EPA, 2000). Risk characterization also serves as the bridge between risk assessment and risk management. This section will also discuss how quantitative risk estimates can be integrated with qualitative and quantitative information regarding uncertainty and variability to characterize risk.

This analysis calculates individual cancer risk which is the risk accruing to an individual in a defined exposure scenario. Individual cancer risk is calculated as the excess risk from the daily incremental dose of asbestos above the background dose and the human cancer risk factor as established by EPA IRIS. The cancer risk factor converts estimated daily dose averaged over a lifetime to an incremental probability. Therefore, cancer risk estimate is defined as the incremental upper bound probability of an individual developing cancer over a lifetime.

There are a number of outdoor and indoor activities that are routinely performed by residents that could result in unacceptable levels of exposure/risk. However, it is not feasible to evaluate risk for each type of activity due to the lack of exposure data. Therefore, this analysis evaluates risks semi-quantitatively and/or qualitatively for only some of the critical activities, and not all types of activities.

2.2.4.1. Risk screening for adult resident

1. <u>Risk estimation for emissions during rototilling exposure scenario (for soil containing <1% asbestos)</u>

   Exposure concentration for asbestos in air = 0.066 f/cc (EPA, December, 2001)
   Inhalation unit risk (IUR) = 0.23 per f/cc (EPA IRIS)
   Exposure duration = 30 years (EPA, 1991b)
   Exposure time = 2 hr/day (adopted from EPA, 2001)
   Exposure frequency = 8 days/year (adopted from EPA, 2001)
   Averaging time for life = 70 years (EPA, 1991b)
   Time weighted factor (TWF) = 2 hr/24 hr x 30 years/70 years x 8 days/365 days = 0.00078

   Cancer risk = Exposure concentration for asbestos in air x Time weighted factor x Inhalation unit risk
   = 0.066 f/cc x 0.23 per f/cc (IUR) x 0.00078 (TWF) = 1.2E-05

   Adult Cancer Risk = 1.2E-05 (CDPHE acceptable risk is 1E-06)

2. <u>Risk estimation for exposures to soils (containing <1% asbestos) due to other activities listed above (e.g., planting trees/bushes, vegetables, and flowers, weeding, and excavating dead bushes/trees)</u>

   Exposure concentration for asbestos in air = 0.019 f/cc (EPA, December, 2001)
   Inhalation unit risk by EPA IRIS = 0.23 per f/cc
   Exposure duration = 30 years (EPA, 1991b)
   Exposure time = 2 hr/day
   Exposure frequency = 20 days/year
   Averaging time = 70 years (EPA, 1991b)
   Time weighted factor (TWF) = 0.00196

   Cancer Risk = 0.019 f/cc x 0.23 per f/cc (IUR) x 0.00196 (TWF) = 8.6 E-06

   Adult Cancer Risk = 8.6E-06 (CDPHE acceptable risk is 1E-06)

3. <u>Risk estimation for exposures during the management of excavated soils (e.g., bagging/sweeping of excavated soils containing 0.1% to 1% chrysotile asbestos)</u>

   (Exposure concentrations for asbestos in air during bagging/sweeping of asbestos contaminated soils are not available. Therefore, the measured airborne fiber concentration of 0.06 to 1.74 f/mL/mg m^{-3} of dust concentration based on Addison et al. (1988) is used for this scenario).

   Exposure concentration for asbestos in air = 0.06 to 1.74 f/mL (Addison et al., 1988)
   Inhalation unit risk by EPA IRIS = 0.23 per f/cc

Exposure duration = 30 years (EPA, 1991b)
Exposure time = 1 hr/day
Exposure frequency = 8 days/year
Averaging time = 70 years (EPA, 1991b)
Time weighted factor = 0.00039

Cancer Risk = 0.06 to 1.74 f/mL x 0.23 per f/cc (IUR) x 0.00039 (TWF) =

5.4E-06 to 1.6E-04

Adult Cancer Risk =5.4E-06 to 1.6E-04 (CDPHE acceptable risk is 1E-06)

4. Cumulative Lifetime excess cancer risk from the above outdoor activities to adult resident

Total excess lifetime cancer risk to the resident based on rototilling, other garden/yard activities, management of excavated soils = 1.2E-05 + 8.6E-06 + 5.4E-06 to1.6E-04 = 2.6E-05 to1.8E-04

Cumulative adult cancer risk for outdoor garden/yard activities = 2.6 E-05 to 1.8E-04 (CDPHE acceptable risk is 1E-06).

2.2.4.2. Risk screening for child exposure scenario during outdoor activities

Two types of outdoor activities are addressed for children: (1) Playing on swings, etc.; and (2) Playing with excavated soils, and helping parents in the management of excavated soils by bagging soil, etc.

1. Risk estimation from exposure to soils (containing <1% asbestos) while playing on swings, etc.

   Type of outdoor recreational activities for children = Mechanical disturbance and emission of soil while playing on swings, slides, etc. with exposed soil surface.

   Exposure concentration for asbestos in air = 0.066 f/cc; assumed to be the same as rototilling exposure scenario
   Inhalation unit risk (IUR) = 0.23 per f/cc (EPA IRIS)
   Exposure duration = 6 years (EPA, 1991b)
   Exposure time = 1 hr/day
   Exposure frequency = 80 days/year
   Averaging time = 70 years (EPA, 1991b)
   Time weighted factor (TWF) = 0.00078

   Cancer risk = 0.066 x 0.23 per f/cc (IUR) x 0.00078 (TWF) = 1.2E-05

   Child cancer risk = 1.2E-05 (CDPHE acceptable level is 1E-06)

2. Risk estimation from exposure to excavated soils (containing 0.1% to 1% chrysotile asbestos) during playing with excavated soils

   Exposure concentration for asbestos in air = 0.06 to 1.74 f/mL (Addison et al., 1988)
   Inhalation unit risk by EPA IRIS = 0.23 per f/cc
   Exposure duration = 6 years (EPA, 1991b)
   Exposure time = 1 hr/day
   Exposure frequency = 15 days/year
   Averaging time = 70 years (EPA, 1991b)
   Time weighted Factor (TWF) = 0.000147

   Cancer risk = 0.06 to 1.74 f/mL x 0.23 per f/cc (IUR) x 0.000147 (TWF) =2E-06 to 5.9E-05

   Child cancer risk = 2E-06 to 6E-05 (CDPHE acceptable level is 1E-06)

3. Cumulative risks for child from various activities

   Total excess lifetime cancer risk to child resident based outdoor activities = 1.2E-05 + 2E-06 to 5.9E-05 = 1.4E-05 to 7.2E-05

   Cumulative child cancer risk for outdoor activities = 1.4E-05 to 7.2E-05 (CDPHE acceptable level is 1E-06)

2.2.5. Uncertainty Analysis

Risk screening analysis is not an exact science. In general, EPA and the Department use assumptions and models that may overestimate risk instead of those that might underestimate the risk in order to make sure that the risk management decisions are protective of the public health. While the EPA risk screening process attempts to estimate risk as accurately as possible, there are numerous sources of uncertainty in the risk screening process (EPA, 1992b; and EPA, 2000). According to EPA, several sources of uncertainty must be considered to place the risk estimates in a proper perspective. These sources range from the estimation of exposure point concentration to the available toxicity information regarding asbestos.

One source that is especially relevant to the asbestos risk screening process is the data on exposure assessment because it represents a snapshot in time. Another important source of uncertainty in this risk screening process related to exposure assessment is the use of activity-specific exposure assumptions to bridge data gaps. Various sources of uncertainty in exposure as well as toxicity data, and risk estimates are briefly discussed below.

2.2.5.1. Uncertainty in exposure assessment

(a) Uncertainties associated with the exposure point concentration

These uncertainties include the estimation methods used to approximate asbestos content of soil and activity-specific concentrations in air. Unfortunately, there are several factors that introduce variability and affect the estimation of exposure point concentration for asbestos fibers in soil or air**.** Some of the major factors are briefly discussed below:

- The estimation of bulk asbestos content in soil is uncertain because soil sampling protocol was designed to detect the presence or absence of asbestos and may not accurately quantify the concentration of asbestos. Therefore, compositing of samples provides potentially diluted results and does not facilitate the detection of hot spots. It is important to note that soil samples that are below the limit of detection by polarized light microscopy (PLM) techniques may show high levels of asbestos fibers by other types of microscopic techniques (e.g., scanning electron microscope (SEM) or transmission electron microscope (TEM)). Moreover, even if the number of fibers by TEM analysis is non-detect, there is at least a 5% chance that the true value could be higher. Therefore, non-detects are generally evaluated by assuming a value equal to half the detection limit in a traditional EPA risk assessment process.

- The concentrations of asbestos in outdoor air specific to certain outdoor activities, are adopted from the studies conducted at the Libby site (EPA, July 2001, and December 2001, Weis Memo) and by Addison et al. (1988). This assumption may over- or under-estimate exposure because the airborne asbestos concentration is governed by a number of factors such as moisture content of soil, nature of soil and fiber, types of soil and fiber, and the amount of asbestos in soil. According to Addison et al. (1988), the most important factor controlling the airborne asbestos concentration that can be generated from any dry soil is the amount of asbestos in soil. This risk screening evaluates risk for exposure to soils containing < 1% asbestos. Therefore, the overall risk may be underestimated, especially, for exposure to soils or debris containing >1% of asbestos. To some extent, the concentration of airborne asbestos is also dependent on the type and nature of fiber and soil; this impact, however, is expected to be minor because Addison et al. (1988) demonstrated that: (i) "…, irrespective of fibre type or soil type, high airborne fibre concentrations (over 20 f ml^{-1}) can be generated from 1% asbestos in dry soil while restricting the respirable dust concentration to the nuisance dust occupational exposure limit (OEL) of 5 mg m^{-3}…" (p.17); and (ii) "Mixtures of asbestos in dry soils with asbestos content as low as 0.001% can produce airborne respirable asbestos concentrations greater than 0.1 f ml^{-1} in dust clouds where the respirable dust concentrations are less than 5 mg m^{-3}." (p. 21).

  Overall, the presence of various types of asbestos (i.e., chrysotile, crocidolite, amosite, and tremolite) in the NWN at Lowry could result in both over-and underestimations of exposure point concentrations.

- The use of an average value for the exposure point concentrations is inconsistent with the EPA guidance and may underestimate risk. EPA recommends the use of the maximum or the 95% upper confidence limit on the mean value for exposure point concentration. It is, however, important to emphasize that short-term peak exposures to asbestos are critical in terms of the cumulative dose because asbestos fibers are retained in the lungs for a long period of time. Therefore, potential influence of episodic exposures needs to be considered qualitatively.

- The estimation of indoor air and dust concentrations of asbestos is uncertain because it provides a snapshot in time under controlled environmental conditions and, therefore, is not considered a good representative of the future potential exposures. Moreover, it is necessary to consider the following in the interpretation of indoor air data, especially, for extrapolation to future exposure scenarios: (i) The majority of the houses are fairly new (<1 to 12 months old), and the problem of asbestos contamination was discovered in early spring and prior to most residents starting outdoor yard/garden activities; (ii) The ground was heavily saturated with moisture as a result of an extremely heavy snow storm in late March, 2003; and (iii) In the interim, that is the time period between the discovery of asbestos and the actual time of indoor air and dust sampling, residents have presumably been very cautious in controlling all types of yard/garden activities. In fact, residents were asked to keep their windows closed. Moreover, beginning in April, developers have helped control dust emissions by providing hay covers on the exposed soils in yards.

(b) <u>Uncertainty associated with exposure activities and exposure parameters</u>

Uncertainty exists regarding the likelihood that the exposure activities evaluated will in fact occur as well as regarding the activities that are not evaluated in this risk screening analysis. Thus uncertainties associated with the various outdoor activities evaluated in this analysis as related to child and adult receptors, and exposure patterns in terms of time/frequency could result in an over- or under-estimation of risk. This analysis tends to underestimate exposure times in comparison to the values recommended by the EPA (EPA EFH, 1997). For example, it is non-conservatively assumed that children would spend only one out of 5-8 hours/day in their yard for outdoor activities. Similarly, for adults, 64 hours/year for garden/yard work are non-conservatively assumed (vs. 40 hr/month recommended by EPA EFH, 1997).

It is, however, important to emphasize that child-specific inhalation rate and body weight values are not used in this analysis. This assumption may underestimate exposures to children because: (i) children are known to have faster breathing rates; and (ii) children's breathing zone is closer to the ground and thus more likely to breath contaminated soil/dust.

2.2.5.2. Uncertainties related to toxicity assessment

It is important to note that the various risk models available for the estimation of cancer risk do not account for the increased lifetime risk of lung cancer due to prior lung disease. Therefore, cancer risks may be underestimated for susceptible subpopulations with prior lung disease. Moreover, risk for non-malignant disease cannot be evaluated because no method is available to calculate noncancer risks for asbestos. In addition, the use of EPA's Inhalation Unit Risk Factor (EPA IRIS, 2003) is likely to over- or underestimate cancer risk based on a comparison with other available risk models (e.g., Hodgson and Darnton, 2000; Camus et al., 1998; Lash et al., 1997; Gustavsson et al., 2002). Moreover, EPA is in the process of reviewing and possibly updating the cancer risk assessment for asbestos as a function of fiber type and size.

2.2.5.3.Uncertainties related to risk estimates

Determination of quantitative risk of health effects to residents from exposure to the four types of asbestos (i.e., chrysotile, crocidolite, tremolite and amosite) found in the NWN of Lowry is challenging due to the various inherent uncertainties related to exposure assessment and toxicity assessment of asbestos as already discussed above. Therefore, risk screening estimates are derived in this analysis. Some of the uncertainties in the risk estimates derived in this analysis are briefly discussed below.

(a) Risk due to exposure to asbestos-contaminated indoor air

There is possible underestimation of the future potential risks because the risk estimates derived in this analysis do not account for risks due to exposure to asbestos-contaminated indoor air. These risk are not derived due to data gaps regarding the future indoor air asbestos concentrations. Typically, in a risk assessment, potential inhalation exposure is evaluated using emission and dispersion models. As noted above, no reliable models are available to predict airborne concentrations of asbestos from asbestos-containing soils or debris. Some modified dust generation models are under consideration for predicting airborne asbestos concentrations (Berman, 2000). It is premature to employ these models due to various limitations/uncertainties. There is uncertainty regarding the actual risks for malignant and nonmalignant asbestos-related diseases that may exist after exposures to lower levels or shorter duration or both. However, the available epidemiological data and extrapolation of data using EPA IRIS risk model (or other models) indicate that low-level exposure can result in asbestos-related diseases. Therefore, the estimated risks from asbestos-contaminated indoor air exposures can be substantial based on the available evidence, as briefly demonstrated below:

(i) Asbestos-contaminated soil or dust that is tracked into homes can create an on-going source of exposure by being re-entrained as a result of routine activities performed by children and adults inside the home. Moreover, physical handling of asbestos-containing debris by children while playing inside homes could create a pathway of significant exposure. As already discussed above, soil/dust containing even 0.001% asbestos is capable of generating unacceptable levels of airborne fibers up to OSHA standards 0.1 f/cc (Addison et al., 1988). Consequently, potential indoor risks will have to be estimated for a continuous lifetime exposure (i.e., 24 hrs/day for 30 years). It is already known that lifetime exposure to even low levels (< 0.01 f/cc) of asbestos in air (or the cumulative lifetime dose of even 0.01 f-year/cc) can result in excess lung cancer risk (ATSDR, 2001; Hodgson and Darton, 2000). For example:

- EPA IRIS calculated that lifetime exposure to asbestos air concentrations of 0.0001 f/mL could result in up to 2 to 4 excess cancer deaths per 100,000 people (ATSDR, 2001).
- Recently, Hodgson and Darnton (2000) have calculated cancer risk in terms of the cumulative exposure dose to the three types of asbestos that are found at Lowry (i.e., chrysotile, crocidoloite, and amosite). These investigators expressed lung cancer and mesothelioma potency of different types of asbestos, based on a recent analysis of 17 cohorts, as a number of excess deaths per 100,000 exposed. Overall, this analysis demonstrates that all three types of asbestos can increase the risk of lung cancer as well as mesothelioma even at a low level of cumulative exposure to 0.01 f-yr/mL.

(ii) EPA's study at the Libby site (EPA, 2001, December, 2001, Weis Memo) demonstrated that routine household activities or special active house cleaning (dusting, sweeping, vacuuming, etc) resulted in elevated asbestos fiber concentrations in the breathing zone of residents (e.g., range of 0.023-0.048 PCME-asbestos f/cc), and risk estimates significantly above the cancer risk level of 1E-04 (i.e. EPA's upper bound acceptable cancer risk level).

In summary, although risk estimate for indoor air exposures are not calculated in this risk screening analysis, the available data (EPA, 2001; Weis memo; ATSDR, 2001; Hodgson and Darton, 2000; and EPA IRIS, 2003) are adequate to support the conclusion that unacceptable health risks to residents could occur as a result of future potential exposures to asbestos-contaminated indoor soil/dust or air.

(b) <u>Risk estimates for children</u>

Risk estimates for children derived in this analysis may underestimate risk because they do not account for higher exposures to children due to their faster breathing rates and their breathing zone being closer to the ground, as already discussed above. Further, risk for children could be underestimated because of their exposure early in life and the availability of the longer latency period for the development of asbestos- related disease.

(c) <u>Noncancer risks</u>

No risk estimates are calculated for noncancer risks because of the unavailability of any method. It is generally believed that non-malignant asbestos-related diseases are caused by long-term heavy exposures (ATSDR, 2001). It is, however, important to emphasize that even short-term intense exposures, of even 1-day, can cause noncancer health effects (ATSDR, 2000). A recent case study discussed a fatal asbestosis after a brief high intensity exposure to amphibole asbestos. About 30 years later, the patient showed pleural abnormalities on chest x-rays but had no symptoms of asbestos-related disease for another 10 years, when fatal asbestosis occurred quickly (Wright et al., 2002).

(d) Risks due to all types of activities and disturbance

This analysis calculates risk only for certain type of activities to represent risk screening estimates. It is not feasible to calculate risk from all sources and all types of activities due to data gaps.

2.2.6. Conclusions of the Risk Screening Analysis

Overall, this risk screening analysis supports the conclusion that common soil intrusive activities could pose unacceptable risks to public health and that additional measures are needed to minimize and/or eliminate potential exposure pathways.

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