CHAPTER 1. RELEVANCE TO PUBLIC HEALTH

1.1 OVERVIEW AND U.S. EXPOSURES

ATSDR's *Toxicological Profile for Thorium* was released in 1990. In order to update the literature in this profile, ATSDR conducted a literature search focused on health effects information as described in Appendix B. Chapters 2 and 3 were revised to reflect the most current health effects data. In some cases, other sections of the profile were updated as needed or for consistency with the updated health effects data. However, the focus of the update to this profile is on health effects information.

Thorium is a radioactive element that occurs naturally in the environment; thus, background levels occur in air, water, and soil. Atmospheric thorium levels above natural background levels occur mainly from mining, milling, and processing operations; phosphate rock processing and phosphate fertilizer production; and coal-fired utilities and industrial boilers. No recent data are available on estimated releases of thorium to the atmosphere, water, or soil from the only domestic manufacturing and processing facility required to report to the Toxics Release Inventory (TRI16 2017).

The most likely sources of exposure of the general population to thorium are from inhalation of air and ingestion of food and drinking water containing thorium. Workers are exposed to higher levels of thorium and other radionuclides in certain thorium industries, as indicated by the measured exhaled breath and tissue levels of these chemicals. However, concentrations of thorium in air, food, and/or drinking water are normally very low and thorium-containing substances are not generally readily absorbed by the body.

1.2 SUMMARY OF HEALTH EFFECTS

- Respiratory disease has been associated with occupational exposure to thorium; workers were also exposed to other radioactive and nonradioactive compounds and other radionuclides.
- Cancer of the lung and blood-producing tissues has been associated with occupational exposure to thorium and other radionuclides.
- Hematological effects and pulmonary effects (cirrhosis and cancer of the lung) were observed in animals following inhalation exposure to thorium.
- Adverse effects on the skin, the testes, and sperm morphology were reported in animals after thorium nitrate was applied on the scrotum.

- Among patients receiving a radioactive colloidal suspension of thorium dioxide ($^{232}ThO_2$) by intravascular injection to visualize selected veins or arteries, adverse effects on the liver and associated organs and tissues, and the reticuloendothelial system were common.

Very little data exist on health effects due to inhalation, oral, or dermal exposure of thorium in humans or animals. It has not been determined whether the adverse health effects associated with exposure to thorium are the result of the ionizing radiation, the chemical toxicity of thorium, or a combination of radiation and chemical toxicity. The small number of epidemiology studies have primarily focused on the potential increases in the risk of cancer deaths in workers exposed to airborne thorium and its progeny radionuclides. Inhalation, oral, and dermal studies in laboratory animals have identified several potential targets of toxicity including the respiratory tract, hematological system, skin, and testes. However, most studies did not find adverse effects.

Some evidence of respiratory disease, liver disease, and increased incidence of pancreatic, lung, and hematopoietic cancers in humans was reported following occupational exposure (Archer et al. 1973; Farid and Conibear 1983; Polednak et al. 1983; Stehney et al. 1980). These effects were seen in thorium workers exposed to many toxic agents; therefore, the effects cannot be positively attributed directly to thorium exposure. Although the studies found some associations, co-exposure to other compounds such as silica (silicon dioxide) and the lack of control for smoking limit the interpretation of these data.

Intermediate-duration animal studies have shown pneumocirrhosis (cirrhosis of the lung), adverse hematological effects, and increased incidences of lung cancer following inhalation exposure to thorium (Hall et al. 1951; Likhachev 1976; Likhachev et al. 1973a, 1973b). Chronic inhalation exposure to low levels of thorium dioxide did not result in adverse effects in rats, rabbits, or dogs (Hodge et al. 1960). Oral studies in animals showed death at high exposure levels, but no other systemic effects were observed (Patrick and Cross 1948). Dermally-administered thorium nitrate in animals showed effects on the skin, the testes, and sperm morphology when administered directly on the scrotum, but no other systemic effects were observed (Tandon et al. 1975).

In addition to these studies, there are a number of studies evaluating the health effects of thorium involved the intravascular injection of a colloidal suspension form of $^{232}ThO_2$, which was produced under the trade name, Thorotrast. Thorotrast exhibited unique physico-chemical characteristics that enabled it to distribute to, and remain within, bone marrow and selected other tissues. These physico-chemical characteristics and the intravascular injection route of exposure to Thorotrast are in contrast to the physico-chemical characteristics of thorium in the natural environment and natural routes of human

exposure to thorium (inhalation, oral, dermal). Therefore, results from Thorotrast-injected patients are not considered an appropriate basis for assessing thorium toxicity apart from colloidal Thorotrast. Thorotrast was used globally during the period 1928–1954. Although the colloid contained various sized particles, some manufacturers eliminated larger particles and retained smaller particles (average size 10 nm) in the range of nanomaterials (Dalheimer et al. 1988). The manufacture and use of Thorotrast ceased when delayed adverse health effects were recognized and attributed to its use. Several cohorts of Thorotrast-injected patients were followed for up to several decades and results were summarized in published reports; the most recent follow-up studies include Becker et al. (2008), dos Santos Silva et al. (2003), Mori et al. (1999b), and Travis et al. (2003). Early reports and follow-up studies identified the liver (and associated organs and tissues) and the reticuloendothelial system as critical targets of Thorotrast toxicity.

1.3 MINIMAL RISK LEVELS (MRLs)

No acute-, intermediate-, or chronic-duration inhalation or oral MRLs were derived for thorium due to a lack of suitable human or animal data regarding health effects following inhalation or oral exposure to thorium and its progeny. Inhalation and oral MRL values are summarized in Table 1-1 and discussed in greater detail in Appendix A.

Table 1-1. Minimal Risk Levels (MRLs) for Thorium[a]

Exposure duration	MRL	Critical effect	Point of departure	Uncertainty factor	Reference
Inhalation exposure					
Acute	Insufficient data for MRL derivation				
Intermediate	Insufficient data for MRL derivation				
Chronic	Insufficient data for MRL derivation				
Oral exposure					
Acute	Insufficient data for MRL derivation				
Intermediate	Insufficient data for MRL derivation				
Chronic	Insufficient data for MRL derivation				

[a]See Appendix A for additional information.