

A Cross-Sectional Study of Asbestos-Related Morbidity and Mortality in Vermonters Residing Near an Asbestos Mine

**Updated
December 9, 2008**

NOTE: Additional findings are presented in a new Vermont Department of Health report, *Case Series Follow-up*, April 1, 2009.

The Health Department conducted further study and found that all of the deaths from asbestosis that occurred in towns surrounding the Vermont Asbestos Group mine during the years 1996 to 2005 can be explained by occupational exposure to asbestos.

There is no evidence that people who live near the mine are more likely to die of non-occupationally contracted asbestos-related diseases than people who live elsewhere in the state.

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Preface

This report has been revised from the original dated November 3, 2008. After an extensive review of the data used for the study, it was determined that lung cancer findings for towns within the 10-mile radius are not significantly higher than the rest of the state. It is not justified to conclude the presence of a statistical increase in lung cancer in the 10-mile radius around the mine.

Introduction

Chrysotile asbestos was mined from three locations on Belvidere Mountain in the northern part of Vermont from the early 1900's to 1993. Mining operations left mill tailings estimated to contain over 29 million tons of asbestos-contaminated waste. Asbestos is still found at the site in various forms, including undisturbed veins of the raw mineral in the quarry walls and several million cubic yards of partially processed rock. Erosion of the tailing piles by both wind and rain has caused significant ecological damage. However, lack of environmental sampling data has created challenges in estimating the risk to human health from exposure from living near and recreating on the partially processed waste rock that is scattered over approximately 1,540 acres.

Inhalation of chrysotile asbestos has been associated with lung cancer, mesothelioma, and asbestosis in workers in numerous epidemiological studies.¹ Studies of workers have shown a dose-response association between the concentration and duration of chrysotile asbestos exposure and the severity of disease. However, few studies have evaluated the risk of developing lung cancer or asbestosis when exposed to chrysotile asbestos by non-occupational means.

In 2006, the Vermont Department of Health (VDH) was approached by the Department of Environmental Conservation (DEC) to assist in developing strategies to understand the risk to Vermonters who lived in close proximity to the asbestos mine located on Belvidere Mountain. Due to limited environmental sampling data and lack of good asbestos risk assessment models, VDH used univariate statistical analyses to assess human health risk. VDH used existing health surveillance data from death certificates, hospital discharge billing records, and cancer registry data for the 10-year period 1996 to 2005 to compare risk of developing lung cancer, asbestosis, and/or mesothelioma in those individuals who lived in the 13 towns closest to the Belvidere Mountain asbestos mine and those living in the rest of the state.

Methods

We defined the geographical area where residents were more likely to be exposed to asbestos based on proximity to the Belvidere Mountain asbestos mine. Exposure was defined as residing in a town that is within a 10-mile radius around the mine. Residents in

¹ WHO, 1998. Chrysotile asbestos: Environmental health criteria. Geneva, Switzerland. World Health Organization.

the following towns were considered exposed to asbestos: Albany, Belvidere, Craftsbury, Eden, Hyde Park, Irasburg, Johnson, Lowell, Montgomery, Newport Town, Troy, Waterville, and Westfield. Some towns that only partially overlap that circle, and are separated from the mine by mountains, were excluded from the area defined as “exposed.” Residents of Enosburg, Bakersfield, and Wolcott, along with those of all other Vermont towns, were considered “unexposed.” Figure 1 shows the proximity of the mine to the rest of the state, and Figure 2 shows more detail of the study area.

Onsite meteorological data are not available. For the past two years, the Vermont Department of Health, in collaboration with the Department of Environmental Conservation, have requested these data from the Vermont Asbestos Group but have been unsuccessful in obtaining them. In absence of onsite data, we therefore estimated a southwesterly sustained wind direction for the area around the asbestos mine. We applied the August 2008 wind rose pattern for the Burlington International Airport (source: Natural Resources Conservation Service), taking into consideration the differences in topography between the Champlain Valley (where Burlington is located), and the valley near the Belvidere Mountain asbestos mine.

Data Sources

The following data sources were identified by the VDH Environmental Health Section and the Vermont Cancer Registry (VCR) for use in the study:

1. Individual death certificates with any mention of asbestosis, pleural malignancy, peritoneal malignancy or mesothelioma were extracted for Vermont residents from the mortality records. Mortality data for Vermont residents who died outside of Vermont were obtained through the Interjurisdictional Exchange Agreement.
2. Hospital discharges with a primary or contributing diagnosis of asbestosis, pleural malignancy or peritoneal malignancy were also obtained. Data were obtained for Vermont residents discharged from Vermont hospitals and hospitals in neighboring states (Massachusetts, New York and New Hampshire).
3. New diagnoses of lung cancer, pleural malignancy, peritoneal malignancy and mesothelioma were obtained from the Vermont Cancer Registry. Cancer incidence represents Vermont residents, including residents diagnosed out of state.
4. Vermont Asbestos Group (VAG) is the current owner of the Belvidere Mountain asbestos mine. A list of VAG employees, with dates of hire from 1928 through 1992, was obtained from the Vermont Attorney General’s Office based on prior court proceedings.
5. Population data were obtained from the VDH Center for Health Statistics, the U.S. Bureau of the Census, and the National Center for Health Statistics.

All deaths, discharges and diagnoses were classified according to the International Classification of Diseases (see Table 1). All data were extracted for the most recent 10-year period available for analysis, 1996 through 2005.

Statistical Analysis

We compared cases who were residents of the exposed towns with cases from the rest of the state (“exposed” having been defined above) by using crude odds ratios (ORs) and standardized mortality (or morbidity) ratios (SMR). Standardized mortality ratios were calculated for death certificate data; standardized morbidity ratios were calculated for hospital discharge and cancer registry data. SMRs were calculated using 10-year age groupings and with the entire population of Vermont as the standard population.

The denominator data (10-year population) for the calculation of the ORs are as follows: 167,007 for the exposed towns and 5,932,612 for the unexposed towns. The age groupings for the SMRs are as follows: 0-4 years, 5-14 years, 15-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years, 75-84 years, 85+ years.

For hospital discharges and death certificate data, due to small numbers, confidence intervals and *p*-values for the ORs were calculated using the mid-P version of Fisher’s exact method. Confidence intervals and *p*-values for the SMRs were calculated using a mid-P method based on the Poisson distribution.

For cancer registry data, confidence intervals for the ORs are based on the Taylor series; *p*-values are two-sided (Mantel-Haenszel chi-squared method). Confidence intervals for the SMRs were calculated using the Rothman/Greenland approximation, and *p*-values are two-sided using the chi-squared method.

For cancer registry and death certificate data, measures of effect were calculated with and without Vermont Asbestos Group employees. We excluded VAG employees to evaluate whether an increased risk of developing asbestos-related conditions existed among residents near the mine who were not likely to have an occupational exposure to asbestos from the mine.

All of the above described methods were reviewed and approved by the Health Surveillance Division Director, the State Epidemiologist for Environmental Health, the Vermont Cancer Registry Chief, and the Public Health Statistics Chief. The methods are considered “best practice” for conducting these types of epidemiological studies with small populations.

Results

All statistically significant results are presented in Table 2. A statistically significant association (OR = 3.03; 95% CI: 1.69- 5.10) was observed between asbestosis as reported by hospital discharge data and residence in a town in close proximity to the mine. Age adjusted results using the standard morbidity ratio (SMR) also revealed a statistically

significant association with the observed number of discharges greater in the towns close to the mine as compared to the Vermont population (SMR = 3.14; 95% CI: 1.79 – 5.15).

According to death certificate data, the odds of living close to the mine are greater among people who have died from asbestosis as among people who have not died from asbestosis (OR = 12.69; 95% CI: 4.10 – 34.21) . This statistically significant association remained after exclusion of VAG employees (OR = 8.88; 95% CI: 1.61 – 32.91). The SMR also supports this finding with residents in close proximity to the mine having a higher risk of dying from asbestosis than residents in Vermont (SMR = 10.46; 95% CI: 3.83 – 23.19). Again, this association remains after removing VAG employees (SMR = 8.07; 95% CI: 2.05 – 21.96).

We reviewed the death certificates with any mention of asbestosis to evaluate whether diagnostic bias was present. Each death certificate in the “exposed” area had a different certifying physician.

No significant findings were found for lung cancer, pleural malignancy, peritoneal malignancy, or mesothelioma.

Discussion

These findings were consistent across two of the databases examined and remained significant even after removing from the analyses those who worked at the mine. The results strongly suggest an increased risk of asbestosis disease and asbestosis death among those who live in close proximity to the mine. However, there are several limitations to this study:

1. The primary limitation of the study is that we are inferring asbestos exposure from residence at a point in time, and we are assessing disease at the same time. Residence at a single point in time may be a poor indicator of current exposure or historic exposure to asbestos.
2. Another significant limitation is that we do not know the length of time each person lived at his or her residence. The hospital discharge, cancer registry, and mortality data sets record residence at the time an event (hospitalization, cancer diagnosis, or death) took place. People who originally lived in the buffer zone and were likely to have asbestos exposure, then moved to another location in Vermont, and were later hospitalized, diagnosed, or died with a specific health condition, would be classified as residing outside the buffer zone and unlikely to have asbestos exposure. The converse is also true.
3. Although the years 1996-2005 are consistently analyzed across each of the data sets, the time of exposure to asbestos was likely earlier than the time of the hospitalization, diagnosis, or death of each study participant.
4. Given the time period studied, our analysis may not include persons who would have been identified as ill before 1996 or persons who have yet to be reported to

VDH after 2005. It is a possibility that further cases will be identified as a result of the length of time from asbestos exposure to disease diagnosis and data collection within public health data sources.

5. Some of the findings of this study are based on very small numbers. For example, the number of events studied could be as low as three. Additionally, the geographic area where people were likely to have asbestos exposure is rural. On average, 16,701 people lived in the buffer zone at any given time during the study (compared to an average of 609,962 for Vermont overall). To compensate for this, we used multiple approaches to assess whether we observed a higher number of health events among people living in the buffer zone than expected. Both odds ratios and standardized mortality (or morbidity) ratios were calculated. We used the mid-P version of Fisher's exact method (for ORs) and used the mid-P method based on the Poisson distribution (for SMRs) when testing statistical significance for small numbers.
6. The VAG employment records may be incomplete because they were based on information that was indirectly obtained from the employer. Several typed lists were data entered, de-duplicated and checked for errors. In the 65 years of employment, it is likely that some employees, particularly temporary or part-time employees, were excluded from the master list that we used to classify people as VAG employees.
7. We could not assess whether people who did not work at VAG were exposed to asbestos by other sources. It is possible that persons residing anywhere in Vermont could have been exposed to asbestos in the workplace. Although occupation and industry are included in the mortality and cancer registry data sets, the data fields are not 100 percent accurate or complete.
8. We combined mesothelioma, all malignancies of the pleura, and all malignancies of the peritoneum due to limitations in coding deaths that occurred before 1999 and hospital discharges of all years. (ICD-9 and ICD-9-CM lacks the specificity needed to separate mesothelioma from different malignancies.) This could have underestimated the difference in pleural and peritoneal mesothelioma that might exist between the buffer zone and the rest of the state.
9. The mortality data are very likely to be undercounts of deaths for the specified causes. There is no national requirement for states to share with each other a copy of the death certificate if a resident dies out of state. It can be assumed with some confidence that there may be long-time Vermont residents who worked and lived in the study area, moved to other states, and died during the study period. We only receive death certificates or notifications reliably from NH, NY, ME, and Canada.
10. In those cases where a Vermont resident died in another state and that state sent us a notification of the death as a courtesy, the VDH Vital Records / Statistics Office is restricted from sharing all of the information with the study group. The

Interjurisdictional Exchange Agreement, signed by all states, stipulates the allowed and disallowed use of birth and death certificate information by other states. The agreement goes into significant detail as to which fields of the certificates may be used by which states for what type of purpose. Some states allow other states to use all of the information. Other states prohibit any type of use.

11. Vermont cancer incidence data are estimated to be 100 percent complete based on evaluation by the Centers for Disease Control and Prevention (CDC) and the North American Association of Central Cancer Registries (NAACCR). However, it is possible that people diagnosed with cancer were unreported by healthcare providers or healthcare facilities. It is also possible that Vermont residents received their diagnosis and first course of treatment in a state that does not have an interstate data exchange agreement and, therefore, would not be reported to the VCR.
12. The Hospital Discharge Data represent discharges, not individuals. By law, we do not have access to the personal identifiers in the hospital discharge data set. A limitation of the study is that we assumed the amount of duplication (multiple discharges per person) is similar in the buffer zone and the rest of the state. However, access to care could be different in different areas of the state.
13. We were unable to establish household contacts of VAG employees because cases were not interviewed.

Conclusion

This study found statistically significant associations between asbestosis disease/death and residence in the 13 towns closest to Belvidere Mountain asbestos mine. Vermonters discharged from the hospital with a diagnosis of asbestosis were statistically more likely to live close to the mine, and Vermonters who died of asbestosis or asbestosis contributed to their death were statistically more likely to live close to the mine.

Although statistically significant increases in asbestosis disease/death were found in those who lived in close proximity to the mine, the study does not identify the cause of the increase. A major limitation of the study is the lack of exposure information. Exposure since the mine closed in 1993 is less likely than during the years when the mine was operational. This is important to note because the diseases we have studied generally take years to develop, pointing to exposure going back further in time. Residency close to the mine is used as an exposure surrogate, but residency may be a poor indicator of actual non-occupation asbestos exposure. The study indicates further asbestos exposure risk assessment is necessary to determine the existence or likelihood of current health risks associated with residence near the mine.

VDH recommends the following:

- A. Complete asbestos exposure health risk assessment including, but not limited to, activity-based sampling, perimeter air sampling, residential home air and wipe sampling, and meteorological data to better understand current off-site migration of asbestos;
- B. Compare the prevalence of pleural plaques in the 13 towns compared to the rest of the state using mortality data from 1999 to 2005. (The latency period for developing asbestos-related pleural plaques is approximately five years. Pleural plaques may be a better indicator of residential non-occupational asbestos exposure);
- C. Evaluate the extent of the off-site use of asbestos mine tailings;
- D. Restrict public access to the asbestos mine.

Table 1. Site group definitions.

Site Group	Hospital Discharge Data (ICD-9-CM)	Deaths occurring before 1999 (ICD-9)	Deaths occurring on or after 1999 (ICD-10)	Cancer Incidence Data (ICD-O-3) Topography Morphology	
Asbestosis	501	501	J61		
Malignant neoplasm of bronchus and lung				C34.0	
				C34.1	invasive
				C34.2	neoplasms
				C34.3	except
				C34.8	9590-9989
				C34.9	
Malignant neoplasm of peritoneum	158	158	C48		
	158.0	158.0	C48.0	C48.0	invasive
	158.8	158.8	C48.1	C48.1	neoplasms
	158.9	158.9	C48.2	C48.2	except
			C48.8	C48.8	9590-9989
Malignant neoplasm of pleura	163	163	C38.4	C38.4	
	163.0	163.0	C38.4	C38.4	invasive
	163.1	163.1	C38.4	C38.4	neoplasms
	163.8	163.8	C38.4	C38.4	except
	163.9	163.9	C38.4	C38.4	9590-9989
Mesothelioma			C45		
			C45.0	C38.4	morphology
			C45.1	C48.2	code M905
			C45.2	C38.0	with behavior
			C45.7	any	code /3
			C45.9	any	

Table 2. Association between asbestos-related disease and living in close proximity¹ to the Belvidere Mountain asbestos mine, 1996-2005.

Health Event	Exposed / Unexposed	OR	95% CI	<i>p</i> -Value	Observed / Expected	SMR	95% CI	<i>p</i> -Value
Hospital Discharge Asbestosis ²	14 / 164	3.03	1.69 – 5.10	0.0006	14 / 4.46	3.14	1.79 – 5.15	<0.0001
Death Certificate Asbestosis ²	5 / 14	12.69	4.10 – 34.21	0.0001	5 / 0.48	10.46	3.83 – 23.19	<0.0001
Death Certificate Asbestosis ² VAG employees excluded	3 / 12	8.88	1.61 – 32.91	0.008	3 / 0.37	8.07	2.05 – 21.96	0.007
Cancer Registry Lung Cancer ³	120 / 4186	1.02	0.85 - 1.22	0.84	120 / 110.97	1.08	0.90 – 1.29	0.39
Cancer Registry Lung Cancer ³ VAG employees excluded	115 / 4183	0.98	0.81 - 1.18	0.80	115 / 110.76	1.04	0.86 – 1.25	0.69

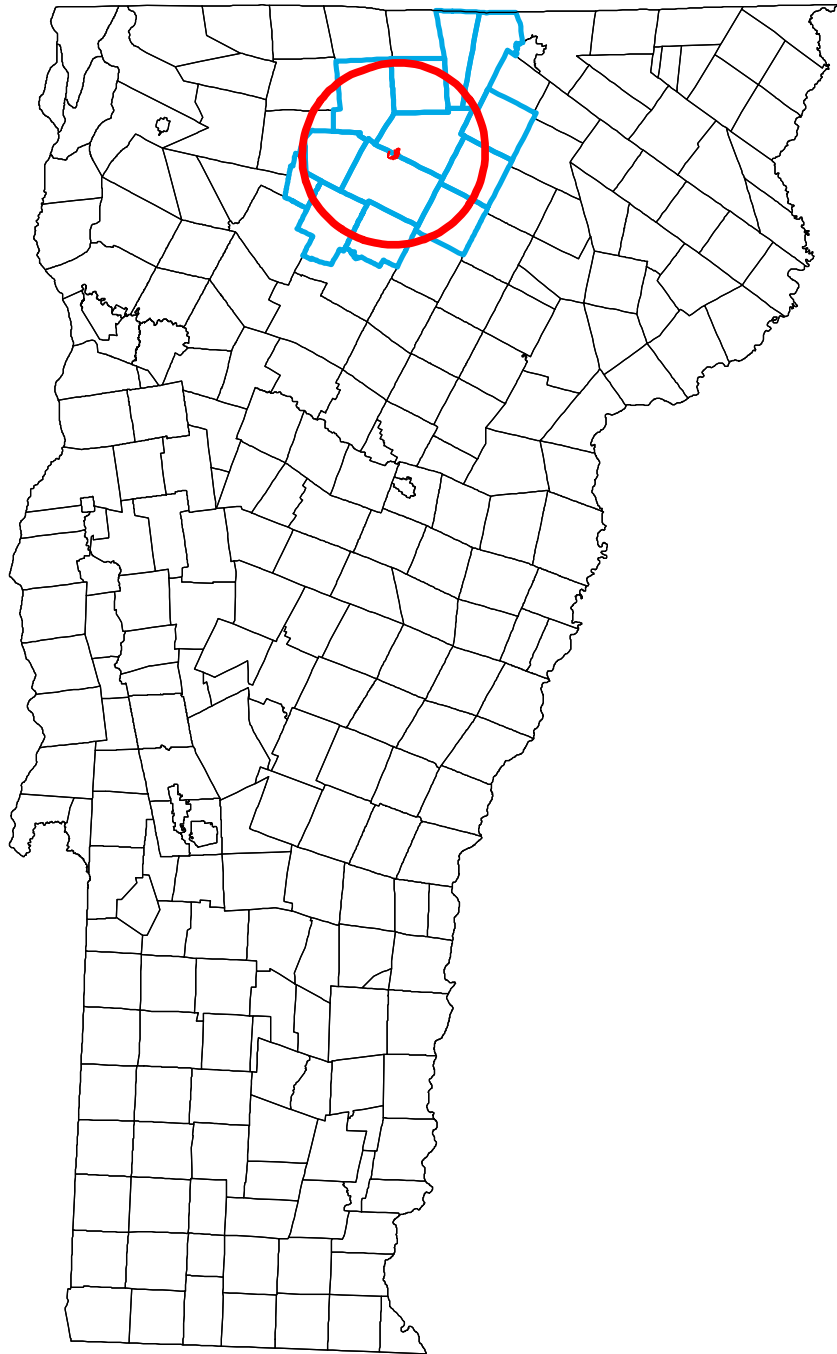
OR, Odds Ratio; CI, Confidence Interval; SMR, Standardized Mortality (Morbidity) Ratio

¹ Vermont towns in close proximity include Albany, Belvidere, Craftsbury, Eden, Hyde Park, Irasburg, Johnson, Lowell, Montgomery, Newport Town (excluding Newport City), Troy, Waterville, and Westfield.

² For hospital discharges and death certificate data, confidence intervals and *p*-values for ORs were calculated using the mid-P version of Fisher's exact method. Confidence intervals and *p*-values for the SMRs were calculated using the mid-P method based on the Poisson distribution.

³ For cancer registry data, confidence intervals for ORs were based on the Taylor series; *p*-values are two-sided (Mantel-Haenszel chi-squared method). Confidence intervals for the SMRs were calculated using the Rothman/Greenland approximation, and *p*-values are two-sided using the chi-squared method.

Figure 1. Asbestos - Related
Morbidity and Mortality
Study Area



Legend





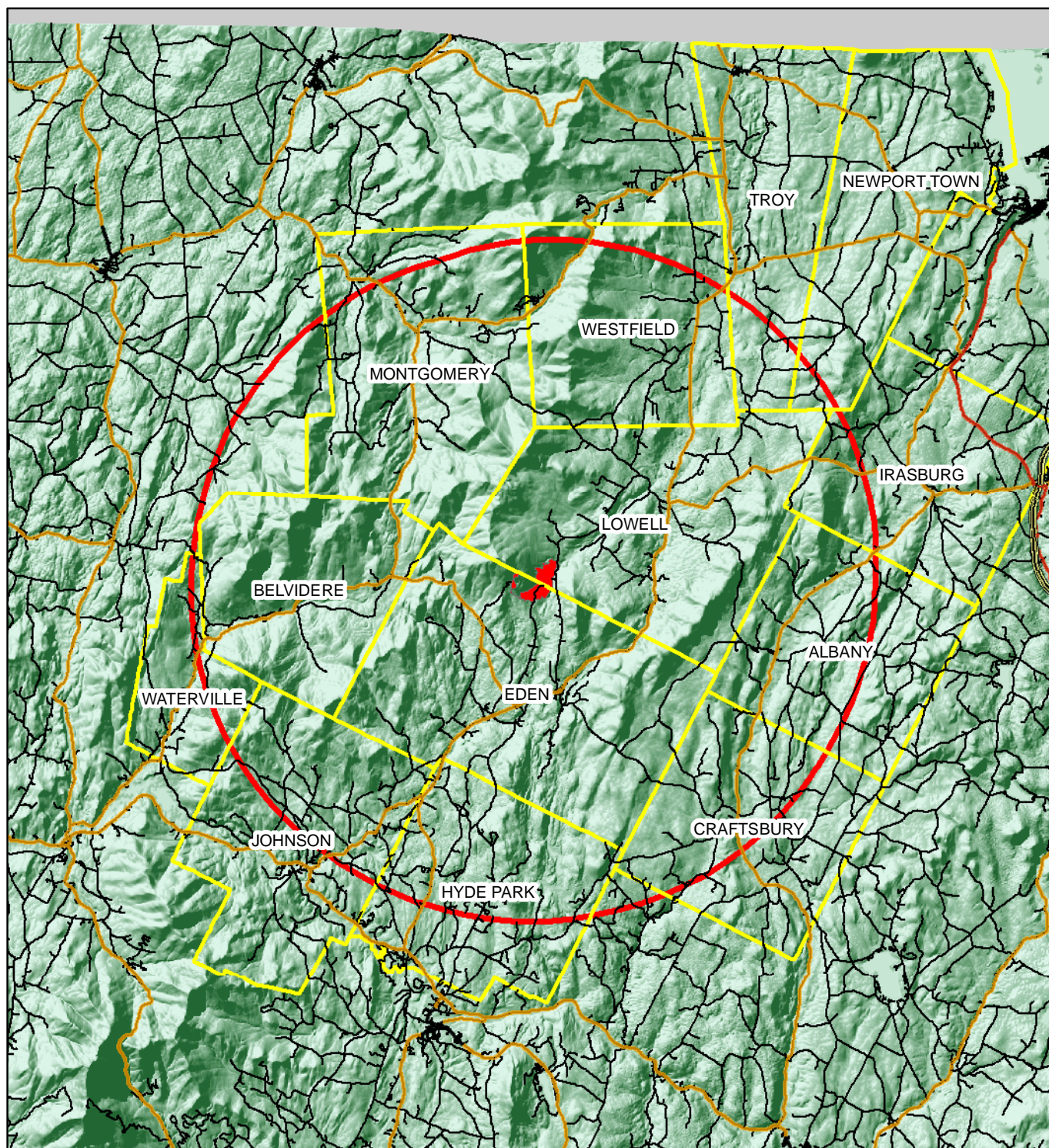








-  Asbestos Mine - 10 Mi. Radius
-  Asbestos Mine
-  Towns Near Asbestos Mine
-  Town Boundaries

Figure 2. Towns Near
Belvidere Mountain
Asbestos Mine



Town Name
Albany
Belvidere
Craftsbury
Eden
Hyde Park
Irasburg
Johnson
Lowell
Montgomery
Newport Town
Troy
Waterville
Westfield

Legend

-  Local Roads
-  State Highways
-  US Highways
-  Interstate Highways
-  Towns Near Asbestos Mine
-  Asbestos Mine - 10 Mi. Radius
-  Asbestos Mine
-  Hillshade Showing Topography