

ANNUAL REPORT TO THE LEGISLATURE
MINNESOTA TACONITE WORKERS HEALTH STUDY

DATE: February 15, 2012

TO: Sen. Geoff Michel, chairman
Senate Jobs and Economic Growth Committee
208 Capitol

Sen. David Hann, chairman
Senate Health and Human Services Committee
328 Capitol

Rep. Steve Gottwalt, chairman
House Health and Human Services Reform Committee
485 State Office Building

Rep. Bob Gunther, chairman
House Jobs and Economic Development Finance Committee
591 State Office Building

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COPIES: *Iron Range Legislative Delegation*
Rep. Tom Anzelc
Sen. Tom Bakk
Rep. David Dill
Rep. Carolyn McElfatrick
Rep. Carly Melin
Rep. Tom Rukavina
Sen. Tom Saxhaug
Sen. David Tomassoni

February 15, 2012

Dear Legislators:

Pursuant to 2008 Minnesota Session Laws, Chapter 248, we are pleased to present the attached report on our research regarding the health status of Minnesota taconite industry workers.

The report details the progress the University of Minnesota School of Public Health is making in the research areas – occupational exposure, mortality and cancer incidence, and the respiratory health survey of taconite workers and spouses – and includes an update from the Natural Resources Research Institute (NRRI) on its environmental study of airborne particles in Iron Range communities.

We are currently moving into the critical phase of combining data from the exposure study with data from the human health studies in order to more clearly understand the lung health of workers in the taconite industry. We continue to make satisfactory progress and expect to complete the project within the projected time estimates. We have included a timeline for project completion within this report.

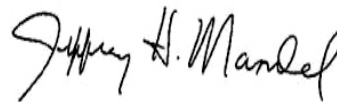
As our scientific research efforts continue, we remain committed to open communication and transparency. We communicate regularly with the broader Iron Range community through the Minnesota Taconite Workers Lung Health Partnership, via our website (<http://www.taconiteworkers.umn.edu>), in our work with the Twin Cities and northeastern Minnesota media, and with various stakeholder groups.

We welcome your comments and suggestions, and would be delighted to discuss the report at a convenient time.

Thank you for the opportunity to advance scientific knowledge on this critical issue facing Minnesota.



John R. Finnegan, Jr., PhD
Professor and Dean



Jeffrey H. Mandel, MD, MPH
Associate Professor
Principal Investigator

Taconite Workers Health Study

Progress Report to the Minnesota Legislature

OVERALL SUMMARY

All five study components have made continued and sufficient progress since the last update. We expect to complete the entire study within the original time and budget estimates. We continue to interact with our scientific advisory boards as we enter the final stages of the work. Activities in the upcoming 6-12 months will be spent completing final dust analyses (occupational and community) and incorporating occupational exposure information into the human health investigations.

All on-site exposure testing was completed this past year. More than 2,000 on-site occupational samples were taken with various methodologies, including samples that will be analyzed using electron microscopy. The on-site samples will be combined with historical samples to obtain insights into past workplace dust levels. Likewise, NRRI has completed the community sampling process. Those samples and lake sediment analyses are in the more complex and final analytic stages.

The mortality and incidence studies have now updated the number of cases of mesothelioma, lung cancer, and non-malignant respiratory disease. This information was shared with stakeholders in our October 2011 meeting. Each of these disease areas is focused on the role of workplace exposures, which will be the final part of these investigations.

The Respiratory Health Survey (RHS) testing component was completed in late 2010. Individuals were informed of their test results. Their physicians were also sent results, depending on whether the individual participants wanted us to do that. Results have not been sent elsewhere, unless specifically requested by the individual participants. Data from the testing within RHS is being analyzed within exposure categories, to obtain key insights into the role of the workplace on lung health.

We are pleased with progress in the communications area. We have continued our Lung Health Partnership meetings roughly twice per year. Our website, www.taconiteworkers.umn.edu, continues to serve as an important link to stakeholders. In 2011, the study web site had 1,390 unique visitors with more than 2,000 visits total. We are developing a communication plan this scientific information may be shared with stakeholders and the general public in a consistent and effective way.

An estimate of when each study component will report findings has been assembled and is shown on the next page. We will update this estimate, as needed, depending on progress within the individual study components.

Minnesota Taconite Workers Health Study Timeline

The Minnesota Taconite Workers Health Study is a University of Minnesota research initiative, funded by the State of Minnesota, to more fully understand taconite worker health issues on Minnesota's Iron Range. The University of Minnesota School of Public Health is partnering on the project with the Medical School and the Natural Resources Research Institute. Results of the study's five components are expected in mid- to late 2012 and early 2013. This timeline is an estimate based on current information and is subject to change as new information becomes available.

Component	Study Purpose	Status	Report Expected
Occupational Exposure Assessment	To understand current and historical worker exposure to components of dust from taconite operations	<ul style="list-style-type: none"> • On-site measurements complete • Historical measurements gathered • Engineering controls assessed • Data being integrated into human health studies 	Mid- to late 2012
Mortality (cause of death) Study	To compare the causes of death among the taconite workers to the general population	<ul style="list-style-type: none"> • Causes of death identified • Data quality control and verification in progress • Data analysis progressing 	Late 2012
Incidence Study (Mesothelioma, Lung Cancer and Non-malignant Respiratory Diseases Sub-studies)	To compare the incidence of diseases of interest among the taconite workers to other groups or the general population	<ul style="list-style-type: none"> • Cases identified • Data verification and quality control assessment on going • Exposures data integration in progress 	Late 2012 or early 2013
Respiratory Health Survey of Taconite Workers and Spouses	To estimate non-malignant respiratory disease in workers and their spouses	<ul style="list-style-type: none"> • Screening complete • Exposure data integration in progress 	Late 2012 or early 2013
Environmental Study of Airborne Particulates	To evaluate the effects of past and present taconite mining emissions on community air quality	<ul style="list-style-type: none"> • Community sampling complete • Detailed analyses in progress 	Mid- to late 2012

Timeline date: 1/24/2012

STUDY COMPONENTS

I. Occupational Exposure Assessment

There are three main goals for the exposure assessment component of this research:

1. Assess historical exposures of workers to health-relevant components of dust from taconite operations (asbestiform and non-asbestiform elongated mineral particles (EMPs), respirable dust, and respirable silica) in the taconite industry for the time period 1955-present to evaluate the relationship between exposures and health effects.
2. Assess current exposures of workers to the health-relevant components of dust from taconite operations in relation to current occupational exposure limits.
3. Evaluate existing practices and methods to reduce worker exposures in this industry and, where appropriate, suggest improvements in these methods.

The following tasks have been accomplished to date:

- We have obtained primary exposure monitoring measurements made in the taconite industry for the time period 1955-present that were abstracted by Dr. John Sheehy in 1986, as well as, data from the Mine Safety and Health Administration, and data collected by the currently operating companies (Cliffs Natural Resources, US Steel, and ArcelorMittal). These data have been compiled and a comprehensive database has been created. We are in the process of conducting statistical analysis on historical data for exposure reconstruction.
- The six mines have been divided into two zones (eastern and western) based on their geographical location in the Iron Range. Each zone's workforce has been divided into approximately 30 similar exposure groups (SEGs). We have finished our assessment of current exposures at all the mines (Northshore mining in Silver Bay and Babbitt, US Steel operations at Minntac and Keetac, ArcelorMittal operations at Minorca, and at Cliffs Natural Resources operations at Hibbtac and Utac). Two workers from each SEG were sampled three times each for EMPs (NIOSH 7400 method) and respirable dust and silica. A subset of the personal samples was also analyzed using TEM (NIOSH 7402 method). Table 1 shows the total number of personal samples obtained. We have also completed the task of obtaining area samples for more detailed microscopic analysis by TEM (ISO 13794 method) that can be used to adjust the personal samples. These are also shown in Table 1. Area samples also include real-time monitoring for particle number, surface area, and mass concentrations. Table 2 shows the total number of real-time area sampling data sets obtained.
- Based on analysis of historical data and current measurements, we have classified the workers into approximately 30 SEGs in the eastern and western zones. An analysis of our measurements also lead us to the following preliminary conclusions:
(a) The asbestiform type of EMP is a very low fraction of the total particulate

exposure and nearly all fiber counts are below the regulatory limit; (b) The respirable dust measurements are nearly all below the regulatory limit; (c) Silica measurements had frequent excursions over the regulatory limit. This is similar to Mine Safety and Health Administration (MSHA) findings.

- We also conducted a detailed study of the efficacy of existing exposure control measures including primary engineering controls (enclosures, ventilation, and particle collectors), work practice and administrative controls, and personal protective equipment. We toured the control systems of all the mines. We measured air velocity into selected enclosures and in selected ducts in four mines, and have compared our findings to the American Conference of Industrial Hygienist (ACGIH) ventilation guidelines. In general, the types of installed controls match ACGIH guidelines, although the velocity into some enclosures is lower than recommended. We have arrived at the following preliminary conclusions: (a) Engineering controls are appropriate for normal operations; (b) Miners may be exposed to dust levels at or over the regulatory limit when making repairs or performing maintenance and respiratory protection should be used under these conditions.

Table 1. Number of personal and area samples by mine and geological zone

Company	Mine	Workers	EMPs (NIOSH 7400)	EMPs (NIOSH 7402)	MOUD I (ISO 13794)	NIOSH 0600	NIOSH 7500
Cliffs	Northshore	56	332	131	286	218	218
US Steel	Keetac	34	230	38	156	127	127
US Steel	Minntac	46	325	58	195	182	182
ArcelorMittal	Minorca	22	151	27	104	86	86
Cliffs	Hibbtac	34	239	44	195	136	136
Cliffs	Utac	48	269	48	260	168	168
Total		240	1546	346	1196	917	917

Table 2. Total number of real-time area sample data sets

Plant	# of SEGs	# of locations	PM1.0	PM2.5	RPM	Ptrak	surface area	size distribution
Northshore	17	23	13	21	22	21	19	22
Keetac	11	11	6	6	11	11	11	6
Minntac	15	15	15	15	15	15	15	15
Minorca	8	8	8	8	8	8	8	8
Hibbtac	15	15	15	15	15	15	15	15
Utac	15	20	20	20	20	19	20	20
Total							518	

II. Mortality and Incidence Studies

The overall objective of this part of the Minnesota Taconite Worker Health Study is to determine whether employment in the taconite industry, and more specifically exposure to dust from taconite mining and processing, is related to developing certain cancers or dying from specific diseases. Given the nature of the dust encountered in this industry, and the previously identified diseases, this study is focusing on mesothelioma, lung cancer, and non-malignant respiratory disease (NMRD). NMRD includes the deaths from all other respiratory diseases apart from cancer, i.e. chronic lung diseases.

The specific objectives are:

1. Compare rates of death in taconite workers to what is expected in non-mining populations to characterize overall health of the workers.
2. Conduct specific studies to evaluate the risk of mesothelioma, lung cancer, and nonmalignant respiratory disease, in relation to the length of employment, jobs held in the taconite industry and estimated exposures to respirable dust, silica, and elongated mineral particles.

To accomplish these objectives the existing cohort of taconite industry workers was linked to mortality records, such as those recorded in the National Death Index, to identify causes of death. The Minnesota Cancer Surveillance System (MCSS) was used to identify the incident cases of cancer arising from these conditions. Because the original cohort included people born as early as the 1860s, the analysis was limited to people born after 1920 so researchers could focus on people who were more likely to have spent a large proportion of their working life when taconite production was prevalent.

To determine how working in the taconite industry is related to these diseases considerable effort was made to review employment records. Classifying the workers by how long they worked and the specific jobs they held was key to estimating past exposures. The process involves abstracting records from various sources and standardizing job titles across the industry. The latter is a process of identifying how similar jobs were described and categorizing them into SEGs based on what the workers did and their potential exposure to dust from mining operations. This process takes into account the mine, the process, and the time period.

Tables 3 and 4, along with the following, summarize the study population:

- A total of 45,532 workers born 1920 or later have been identified for this analysis.
- 30,660 individuals were determined to be alive through 2007. There were 13,658 deaths identified that could be classified by cause. Another 266 individuals are presumed dead, but death certificates have not yet been located. Researchers have identified 751 individuals who are presumed to be alive and 197 who did not have enough information to classify as alive or deceased.

- A total of 63 cases of mesothelioma and 993 cases of lung cancer have been identified by linking the cohort with MCSS.
- The mortality records have identified an additional 688 lung cancer cases and an additional 17 potential cases of mesothelioma.

Table 3. Vital Status of Taconite Worker Health Study Population Born 1920 or Later

Status	N
Alive	30,660
Deceased cause of death known	13,658
Presumed dead	266
Presumed alive	751
Unknown	197
Total*	45,532

*Subject to change as work histories are reviewed

Table 4. Diseases of Interest from MCSS^a and Death Certificates

	Mesothelioma	Lung Cancer ^b	NMRD ^{bc}
MCSS only	63	993	na
Death Certificate only	17	688	645
Total	80	1681	645

a: MCSS = Minnesota Cancer Surveillance System

b: Born 1920 or later

c: NMRD = Nonmalignant respiratory disease.

The following tasks for the study have been accomplished:

- The historical work history records have been abstracted for the mesothelioma, lung cancer, and NMRD cases and their respective control populations.
- Systematic review and coding of the abstracted jobs into SEGs has been completed and is under final review.

- Preliminary analyses of the mortality rates of taconite workers compared to the rest of Minnesota have been completed. Further data validation/verification is needed and underway.

As the analyses progress additional efforts will be made to validate data, identify missing information, and determine if supplementary data are available. A major effort at this time is to map all of the work history data to the specific exposure information from the exposure reconstruction portion of the study.

III. Respiratory Health Survey

Since the completion of the participant clinics in Virginia and Silver Bay in late 2010, the Respiratory Health Survey (RHS) researchers have been working with three radiologists to interpret the chest X-rays and having staff compile the lung function test data. Our current focus is on analysis of the lung function tests and the chest X-rays.

In order for lung function abnormalities to be accurately captured, three specific types of breathing tests were performed in the research clinic, including spirometry, diffusion capacity testing (DLCO), and alveolar volume determination. These are done differently, but are each designed to assess the lungs for the types of abnormalities that can occur from dust exposure. The study team is in the process of comparing the findings from these different breathing tests, to best assess the amount of dust-related lung function abnormalities present in this population.

All chest X-rays have been interpreted by two independent radiologists who specialize in reading X-rays from workers exposed to dusts (B-readers). A sample of 10% of these films were read a second time by the same radiologists, to determine how consistent each reader has been. For any X-rays where important differences between the two radiologists existed, an additional read by a third, independent radiologist was undertaken. Results from these X-ray readings are being analyzed to determine the amount of dust-related lung disease as detected on chest X-ray. The combination of the breathing tests along with chest X-rays will enhance the accuracy of determining of the presence of dust-related lung disease.

Preliminary descriptive results from the RHS component were presented at the October, 2011 Lung Health Partnership meeting. The following summarizes points made during the presentation:

- 1188 workers participated
- 498 spouses participated
- 134 workers partially participated (completed questionnaire only)
- Spirometry results indicated that around 17% had lower amounts of forced exhaled air volume than expected (an abnormality commonly seen in people with asthma or emphysema)
- About 4-6% had lower amounts of inhaled and exhaled air volume than expected (an abnormality more commonly seen from dust exposure)

- Chest X-ray results indicated around 15% of participants had abnormalities involving the tissue surrounding the lungs (pleura)
- Around 6% had abnormalities involving the lung tissue (parenchyma)
- All findings have been reported back to individual participants and, at the participants' requests, to their doctors

We are currently analyzing the data to look at issues such as how do the results compare to other groups and what are the effects of smoking combined with dust-related lung disease.

Another important part of the RHS component currently in progress is a comparison of the participants to the non-participants. This is important in helping researchers understand how representative the group of participants is and, ultimately, how well results may be generalized. This work will be completed during 2012.

The final, critical part of the RHS is currently underway. This part of the study incorporates exposure information into the above findings. The primary reason for utilizing exposure information is to see if those participants who had the most significant findings were also the same individuals with the greatest exposure. This process is in the early stages of assessment, but is expected to be completed by the end of 2012.

IV. Environmental Study of Airborne Particulates - NRRI

During 2011, the Natural Resources Research Institute Environmental Exposure Characterization Study completed numerous tasks including sampling, sample submission to external laboratories, sample analysis at the NRRI, lake sediment sample analysis, presentations at professional conferences, and training. An update on these various study components is provided here.

Sampling Events – Communities: Community air sampling is now completed. An eighth community sampling site located on the roof of the Mechanical Engineering Building at the University of Minnesota Twin Cities Campus was added to the seven original community sampling sites located in northeastern Minnesota. Each of the eight community sampling sites has been sampled a minimum of three times during winter (November through April) and three times during summer (May through October). Total sampling events for each of the community sampling sites are summarized below:

- Iron Range Communities
 - Silver Bay High School 11 sampling events (4 winter, 7 summer)
 - Virginia Court House 9 sampling events (4 winter, 5 summer)
 - Hibbing High School 9 sampling events (4 winter, 5 summer)
 - Keewatin Elem. School 6 sampling events (3 winter, 3 summer)
 - Babbitt Municipal Building 15 sampling events (7 winter, 8 summer)
- Non-Iron Range Communities
 - Duluth NRRI Rooftop 10 sampling events (4 winter, 6 summer)
 - Ely Fernberg Site 7 sampling events (4 winter, 3 summer)
 - UMTC Mech. Engineering 6 sampling events (3 winter, 3 summer)

Sampling Events – Taconite Operations: Sampling at the six taconite processing facilities on the Mesabi Iron Range is completed for this study. At each plant, four locations were sampled, including: 1) crusher, 2) magnetic separator, 3) agglomerator/ball drums, and 4) kiln pellet discharge area. All plants have been sampled at least once during active operations (active). Several plants were also sampled during plant shutdowns (inactive). Total sampling events for each of the taconite processing plants are summarized below:

- Utac 2 sampling events (2 active)
- Hibtac 2 sampling events (1 active, 1 inactive)
- Minntac 1 sampling event (1 active)
- Keetac 2 sampling events (1 active, 1 inactive)
- Northshore 4 sampling events (3 active, 1 inactive)
- Minorca 3 sampling events (3 active)

Samples Submitted for Analysis (External Laboratories):

During 2011, 142 samples were submitted for various analyses at external laboratories. These included:

- 27 samples were submitted to Braun Intertec Corporation (Bloomington, Minnesota) for Minnesota Department of Health transmission electron microscopy (TEM) analysis for mineral fibers in air (MDH 852 Method)
- 59 samples were submitted to Elemental Analysis, Inc. (Lexington, Kentucky) for proton-induced X-ray emission (PIXE) analyses;
- 59 samples were submitted to EMSL Analytical (Minneapolis, MN) for TEM analysis of sub-micron particulate utilizing International Standards Organization (ISO) Method 13794.

Since spring, 2009, the NRRI has submitted the following number of samples for the following types of analyses:

- 127 samples were submitted to Braun Intertec Corporation (Bloomington, Minnesota) for Minnesota Department of Health transmission electron microscopy (TEM) analysis for mineral fibers in air (MDH 852 Method)
- 261 samples were submitted to Elemental Analysis, Inc. (Lexington, Kentucky) for proton-induced X-ray emission (PIXE) analyses
- 256 samples were submitted to EMSL Analytical (Minneapolis, MN) for TEM analysis of sub-micron particulate utilizing International Standards Organization (ISO) Method 13794.
- 10 samples were submitted to EMS Laboratories (Pasadena, California) for determination of asbestos content via the Modified Elutriator Method (Berman and Kolk, 1997).

The NRRI is currently evaluating the results, and developing a geographic information system (GIS) to aid in interpreting and reporting the results. Reports containing these results are anticipated by late 2012.

Samples Submitted for Analysis (Natural Resources Research Institute): Sample analyses performed by Natural Resources Research Institute personnel included:

- gravimetric analyses were completed on particulate samples collected during the 2011 community and taconite operation sampling events
- scanning electron microscopy (SEM) analysis was completed on 38 samples, with several of these samples also undergoing energy dispersive spectrometry (EDS) analysis. Numerous samples remain to be analyzed during the first quarter of 2012.

Lake Sediment Samples (Natural Resources Research Institute): Lake sediment core samples collected at two sites (one site near the Northshore/Dunka Pit (“North of Snort” Lake) and the other site within the limits of the City of Virginia (Silver Lake) have been processed and dated using Pb-210 and Cs-137 methodologies. Chemical, mineralogical, and microscopic analysis of dated sediment intervals is ongoing.

Conference Presentations: One poster was presented at a professional conference in 2010. This poster presentation is available on the NRRI website (<http://www.nrri.umn.edu/egg/presentations.html>).

- Hudak, G., Monson Geerts, S., Zanko, L., Severson, A., Severson, A., and Bandli, B., 2011, The Minnesota Taconite Workers Health Study: Environmental Study of Airborne Particulates – 2011 Update: *in* Fitz, T., Mills, A., Wilson, K., Bodette, C., and Cramer, D., eds., 2011, Institute on Lake Superior Geology, Proceedings Volume 57, Part 1 – Programs and Abstracts, p. 46-47.

Training: All NRRI personnel involved in this project received Mine Safety and Health Administration (MSHA) annual update training during 2010. As well, two NRRI researchers (Steven Monson Geerts and Lawrence Zanko) participated in the 2011 ASTM Johnson Conference held in Burlington, Vermont from July 25-July 29, 2011.

Reports in Preparation

Several reports are currently in preparation or planned for 2012. These include:

- Summary of Gravimetric Data Collected During In-Plant Air Sampling (completed and in review)
- Minnesota Taconite Workers Health Study: Development of Standard Operating Procedures for Particle Collection and Gravimetric Analysis (completed and in review)
- Summary of Gravimetric Data Collected During Community Air Sampling (in progress, completion expected in 2012)
- Quality Assurance Project Plan (QAPP) (in progress, completion expected in 2012)
- Glossary of Selected Terminology for the Environmental Study of Airborne Particulates for the Minnesota Taconite Workers Lung Health Partnership (in progress, completion expected in 2012)

- Final Report, Environmental Study of Airborne Particulates for the Minnesota Taconite Workers Lung Health Partnership (in progress – completion expected in 2012)