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**FEASIBILITY INVESTIGATION OF WORKER EXPOSURE TO
TRICHLOROETHYLENE AT THE VIEW-MASTER FACTORY IN
BEAVERTON, OREGON**

SUBMITTED BY

**ENVIRONMENTAL AND OCCUPATIONAL EPIDEMIOLOGY
OREGON DEPARTMENT OF HUMAN SERVICES
PORTLAND, OREGON**

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I. ABSTRACT

The View-Master stereoscopic slide viewer has been a popular children's toy since the 1950s. For nearly half a century, the sole U.S. manufacturing site for the View-Master product was a factory located on Hall Boulevard in Beaverton, Oregon. Throughout this period, an on-site supply well provided water for industrial purposes and for human consumption. In March 1998, chemical analysis of the View-Master factory supply well revealed the presence of the degreasing solvent trichloroethylene (TCE) at concentrations as high as 1,670 micrograms per liter ($\mu\text{g/L}$)—the U.S. Environmental Protection Agency maximum contaminant level is 5 $\mu\text{g/L}$. Soon after the contamination was discovered, the View-Master supply well was shut down. Up to 25,000 people worked at the plant and may have been exposed to the TCE contamination.

In September of 2001, the Oregon Department of Human Services (ODHS) entered into a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR) to determine both the need for and the feasibility of an epidemiological study of the View-Master site. In this report, ODHS compiles the findings of the feasibility investigation of worker exposure to TCE at the View-Master factory.

On the basis of the levels of TCE found in the supply well, the past use of the well as a source of drinking water, and the potential for adverse health effects resulting from past exposure to TCE, ODHS determined that the site posed a public health hazard to people who worked at or visited the plant prior to the discovery of the contamination. Because the use of the View-Master supply well was discontinued when the contamination was discovered in March 1998, the View-Master supply well does not pose a current public health hazard. No other drinking water wells tap into the contaminated aquifer, and the long-term remediation efforts appear to be containing the contamination.

ATSDR and ODHS obtained a list of 13,700 former plant workers from the Mattel Corporation. In collaboration with ATSDR, ODHS conducted a preliminary analysis of mortality and identified excesses in the proportions of deaths due to kidney cancer and pancreatic cancer among the factory's former employees. Although this analysis was limited by the lack of information about the entire worker population and individual exposures to TCE, the preliminary findings underscore the need to fully investigate the impact of TCE exposure on the population of former View-Master workers.

The findings of this feasibility investigation are:

- TCE appears to have been the primary contaminant of the drinking water at the plant;
- Contamination was likely present for a long period of time (estimated to have been present in the groundwater since the mid-1960s);
- A large number of people were likely exposed to the contamination;
- The primary route of exposure (for the last 18 years the factory operated) was through contaminated drinking water;

- Levels of TCE contamination were 300 times the maximum contaminant levels; and
- A significant portion of the former workers or their next of kin can indeed be located and invited to participate in a public health evaluation of their exposures.

Therefore, ODHS recommends further investigation to include the following:

1. A fate and transport assessment to better establish when TCE reached the supply well, and to provide a historical understanding of the concentration of TCE in the well, and
2. Epidemiological studies among former workers to determine their exposure and whether they have experienced adverse health and reproductive outcomes associated with TCE exposure at the plant, to determine the mortality experience of the population, and to document the cancer incidence in this population.

II. BACKGROUND

II.A. TCE Contamination at the View-Master Plant

The View-Master plant ([Figure 1](#)) originally manufactured photographic equipment, slide projectors, and other products, in addition to View-Master viewers. There were five main companies ([Figure 2](#)) that operated the plant between 1951 and 1998. Sawyer's was the founding company. Sawyer's was purchased by General Aniline and Film (GAF) Corporation in 1967. In 1981, GAF sold the operation of this plant to View-Master Corporation. View-Master was acquired by Tyco Toys in 1989. Tyco Toys was acquired by Mattel Corporation in 1997. Mattel stopped production at the Beaverton plant in 1998, when the operations were moved to a factory in Mexico.

Specific plant operations included preparing metal parts (metal stamping, cleaning, and painting), creating plastic parts by injection molding, lens grinding, assembly, photographic production, and printing of packaging and reels. Metal parts were degreased with TCE, and most of the degreasing occurred in one building known as the "Paint Shop." TCE was used in large quantities¹ for vapor degreasing until 1980, at which time GAF phased out the manufacture of slide and movie projectors that required metal parts for assembly (1).

Historical practices resulted in releases of hazardous substances at the site. Former GAF employees report that waste TCE from the degreaser was routinely placed in 55-gallon drums, transported by truck to other sites on the premises, and discharged to the ground. Frequent chemical spills allegedly occurred in the paint shop, and an inspection of the degreaser in 1964 determined that TCE vapors near the degreaser exceeded threshold limits¹.

II.B. Detection and Concentrations of TCE, PCE and DCE

In March 1998, Mattel Corporation contracted with an environmental consulting firm, SECOR, to conduct an environmental assessment of the View-Master site. As part of its investigation, SECOR analyzed samples from the on-site production well. During the original construction of the facility in 1950, the 160-foot-deep well was drilled to supply water for drinking, sanitation, fire suppression, and industrial use. Because the plant was located in a rural location, municipal water was not available until several years after the plant opened. Initial use of municipal water was for fire suppression. It is not known when or to what extent municipal sources were used for drinking water.

SECOR's analyses of initial samples indicate that the on-site water supply well had up to 1,520 µg/L of TCE (2). The EPA has set a maximum contaminant level for TCE in drinking water at 5 µg/L, or 5 parts of TCE per billion (ppb) parts water. SECOR's analyses also detected two other VOCs in the production well: cis-1,2-dichloroethylene (DCE) and tetrachloroethylene (PCE), at levels of up to 33 µg/L and 56 µg/L,

¹ A GAF list of chemicals dated July 1, 1980 (1), refers to 200 gallons per month historic TCE use.

respectively. The maximum contaminant level (MCL) for cis-1,2-DCE is 70 µg/L and the MCL for PCE is 5 µg/L.

Seattle-based Hart Crowser Earth and Environmental Technologies collected verification samples from the well that confirmed the presence of TCE above maximum contaminant levels (3). [Table 1](#) shows the levels of VOCs that were detected in the View-Master supply well, and the MCLs for each chemical.

In addition to TCE, PCE was detected in the View-Master supply well at levels above the MCL. PCE is commonly found at concentrations of 1-3% in the solvent-grade TCE used in manufacturing processes. The presence of PCE in solvent-grade TCE is a by-product of the chemical processes used in the production of TCE. The proportion of PCE to TCE found in the View-Master supply well is consistent with the proportion that occurs in solvent grade TCE.

Low levels of cis-1,2-DCE were detected in the supply well. The presence of this substance is probably attributable to the decomposition of other chlorinated chemicals in the well. Cis-1,2-DCE is considered a non-carcinogen, and the EPA has given the chemical a “not classifiable” or non-cancer rating. The quantity of cis-1,2-DCE observed in the well was within federal safety limits.

II.C. TCE as a Human Carcinogen

TCE has been shown to cause liver and kidney cancer in experimental animals and the EPA has classified TCE as a probable carcinogen for humans. Studies on the epidemiology of cancer among people exposed to TCE have found increases in kidney cancer, liver cancer, non-Hodgkin’s lymphoma, cervical cancer, Hodgkin’s disease, multiple myeloma, and pancreatic cancer, although the association between exposure to TCE and cancer has been inconsistent across studies (4,5,6). TCE has also been linked with a variety of noncancerous conditions, including anemia and other blood disorders, stroke, urinary tract disorders, liver problems, kidney dysfunction, diabetes, eczema, and skin allergies (7).

Both PCE and TCE are suspected carcinogens (8,9). The average concentration of PCE detected in the View-Master supply well was less than 9 times the federal safety standard for PCE in drinking water. The average concentration of TCE, however, was nearly 300 times the federal safety standard. While it may not be possible to separate the health effects of PCE and TCE when the two are found in combination, the likelihood is low that one carcinogenic component representing 1-3% of a mixed contaminant would have a greater impact on the human body than a comparably carcinogenic component representing 97-99% of the contaminant. Moreover, because the solvent product referred to as TCE commonly contains a small amount of PCE, an investigation of health effects at the View-Master site would provide meaningful information for other sites where solvent-grade TCE has contaminated the groundwater.

The potentially exposed population at the View-Master site includes those whose exposure occurred in utero. Studies have linked prenatal TCE exposure with congenital

heart disease, eye malformations, neural tube defects, and oral cleft palates (9,10). The combined results of these studies are unclear, however, and further study is needed to understand the risk of reproductive and developmental effects associated with TCE exposure.

The children of employees may have consumed TCE-contaminated water during visits to the View-Master factory. Children might be more vulnerable than adults to TCE exposure because of age-dependent differences in metabolism, and because children could be at greater risk than adults for organ damage if toxic exposures occur during critical growth stages. Children listed in the National Exposure Subregistry of persons exposed to TCE were reported to have higher rates of hearing and speech impairment (7). An elevated incidence of childhood leukemia was observed among people in Woburn, Massachusetts, who used water for several years from two wells that were contaminated with TCE and other chemicals (11).

In April 1998, ODHS informed ATSDR about the drinking water contamination at the View-Master site, and the two agencies undertook a review of the existing information about the site. In September 2001, ODHS entered a cooperative agreement with ATSDR to investigate the need for and the feasibility of an epidemiological study of the View-Master site. The cooperative agreement was extended for a second year and ended on September 30, 2003. This report summarizes the activities and accomplishments under the stated objectives of the agreement. (See IV. Objectives of the Feasibility Investigation.)

III. PROJECT PERSONNEL

III.A Oregon Department of Human Services (ODHS) Staff

The original Principal Investigator for this feasibility study was Karen Southwick, M.D., MPH. In August 2002, Dr. Southwick left ODHS and was replaced by Michael Heumann, MPH, MA, the Manager of the Environmental and Occupational Epidemiology Section of ODHS. The full-time lead epidemiologist on the project was Michele Freeman, MPH, who was hired in March 2002. Elizabeth Everman served as the half-time support person on the cooperative agreement. At the conclusion of the feasibility study, ODHS applied to the ATSDR 1043 program to add the epidemiologist position to the Oregon 1043 program team in order to maintain some continuity to the work on the View-Master site as well as to provide epidemiological expertise to other Oregon sites. ATSDR was able to provide funding for the position at a 0.75 Full Time Equivalent.

III.B Technical Advisors

ODHS sought the assistance of technical specialists to serve as advisors to the project staff. Advisors include:

Jan Semenza, Ph.D., MPH, Portland State University, Department of Community Health;
Donald Austin, M.D., MPH, Oregon Health and Sciences University, School of Public
Health and Preventive Medicine;
William Lambert, Ph.D., MPH, Oregon Health and Sciences University, Center for
Research on Environmental and Occupational Toxicology.

Dr. Semenza has a background in microbiological research. Dr. Austin is a cancer epidemiologist. Dr. Lambert is a solvent epidemiologist. In November 2003, Daniel Wartenberg, Ph.D., of the Environmental and Occupational Health Sciences Institute at Rutgers University, met with ODHS staff. He is interested in joining the technical advisory team on the View-Master project.

IV. OBJECTIVES OF THE FEASIBILITY INVESTIGATION

The primary objectives that ODHS originally proposed for the feasibility study were the following:

- A. Develop an occupational cohort of former employees of the View-Master factory,
- B. Collaborate with ATSDR to conduct a mortality study of the former workers,
- C. Work closely with the worker community and Mattel to ensure that all involved parties support the health study process, and
- D. Develop a questionnaire and a plan for sampling workers to determine the level of TCE exposure of employees and health outcomes.

In addition to the original objectives of the cooperative agreement, ODHS completed a variety of other activities related to the View-Master project. All of these are discussed below.

IV.A. Develop an Occupational Cohort of Former Employees of the View-Master factory

To reconstruct the cohort of former workers, ODHS met with representatives of both GAF and Mattel Corporations. These are the two remaining companies that represent the operators of the View-Master plant during the years of operation. GAF, represented by G1-Holdings, is currently in bankruptcy and declined to assist ODHS efforts. Negotiations with Mattel Corporation were more positive. Both companies stated that there are no formal records with information about former workers. The number of people potentially affected at the View-Master site is estimated by Mattel Corporation to be as great as 20,000 - 25,000. At its height, the plant was one of the largest manufacturing facilities in Beaverton, employing more than 1,000 people at a time.

A.1. List of Former Workers

ODHS learned that Mattel created a data list of former workers at the time the plant was closing. The data list was originally developed by Mattel as a way to correspond with former employees, to keep them informed about site clean-up activities and a health

screening exam program set up by Mattel for former workers and their children. Mattel entered into separate agreements with ATSDR and ODHS to provide the list of approximately 13,700 people who were employed at the factory during the years 1951 to 1998. Mattel released the employee list to ATSDR in September of 2001. In May of 2002, Mattel agreed to release an updated list of former employees to ODHS, and further agreed to provide ODHS with quarterly updates of the list. The list comprises 6,857 individuals who worked for Sawyer's or GAF during the years 1951 to 1981 (GAF Period), 6,468 who worked for Mattel or Mattel's subsidiaries during 1981 to 1998 (Mattel Period), and 373 who worked during both periods. Information contained on the data list includes the name of the worker, a single date of hire, an address, and for some a telephone number and a social security number.

ODHS continues to augment the list of former workers through direct contact with former workers and community advocacy groups such as the Oregon Center for Environmental Health. Public response to periodic media coverage of the View-Master plant and related issues is an additional source of information about former workers and their families. People regularly contact the ORDHS office in response to an article in a local newspaper or a story on television or radio. The formation of the View-Master Community Advisory Group (CAG) has also created new opportunities to expand the list of employees through word-of-mouth contact.

ODHS used skip-tracing methods as a way to locate current addresses former employees on the Mattel list that lack an effective address. Skip-tracing was conducted by ODHS staff and by a research assistant at Portland State University. This was a time-consuming task that did not easily yield accurate information.

A.2. Internal Revenue and Social Security Administration Efforts

In November 2002, the Office of the Attorney General for ODHS determined from the Office of Legal Counsel of the Social Security Administration (SSA) that ODHS is authorized to use social security numbers to locate participants for an epidemiological study. The SSA confirmed that ODHS may use social security numbers to obtain current addresses, death certificates, or other information about former View-Master workers for the public health study.

Mattel believed their data list represents a complete record of all former employees from the Mattel period (1981-1998). In order to verify the completeness of the Mattel employee data list, ODHS approached the U.S. Internal Revenue Service (IRS) to learn if it would be possible to access tax records. During the Mattel Period all employers used a single unique federal identification number for the Hall Street Plant. ODHS is actively negotiating with Mattel to authorize ODHS access to the IRS records. Mattel is working with the IRS to develop a list of the people employed during the Mattel Period.

It may not be feasible, however, to use IRS records to identify people employed during the GAF period because GAF had employees at more than 200 sites throughout the country, and GAF used the same federal identification number for all sites in filing

employer tax reports to IRS. ODHS developed a Memorandum of Agreement with G1-Holdings in July of 2002 to request a cost estimate from the IRS for the acquisition of historic tax documents for Sawyer's Inc. and GAF employees. ODHS's efforts to reach agreement with GAF for the retrieval of records from historic View-Master operations have been unsuccessful. G1-Holdings declined to perform any of the proposed actions to obtain a cost estimate from IRS. GAF is in bankruptcy proceedings, and may not be able to assist ODHS with the retrieval of records from historic View-Master operations.

A.3. Other Methods to Locate Former Workers

ODHS learned from former workers that during an economic downturn during the 1970s, a number of former workers began working at Tektronix after being laid off from the View-Master factory. ODHS submitted an article to the Tektronix retiree newsletter to inform the Tektronix readership about the contamination at View-Master. The article was published in the November 2002 edition of the newsletter. ODHS received several calls from former View-Master workers who learned about the View-Master contamination from the Tektronix newsletter.

A.4. Evaluation of Efforts to Reconstruct the Cohort

Mattel's database of 13,700 former employees serves as the primary source of information for the occupational cohort, and Mattel continues to provide updates to the list. Given that Mattel estimates total employment maybe as many as 25,000 individuals, this list accounts for between 55-68% of the estimated total workforce at the plant. ODHS continues to receive additional entries to the employee database as former workers learn of the work being done to evaluate the site through other workers, multiple web-sites related to the View-Master site, ODHS and Mattel outreach efforts, the Community Advisory Group and several community advocacy groups.

Mattel asserts that the 6,468 people who reportedly worked during the Mattel period and the 373 who worked during parts of both periods represents the complete cohort of employees at the View-Master plant during the Mattel period. These estimates will be confirmed with the acquisition of the IRS data. The remaining 6,857 workers from the GAF period represent an incomplete sub-cohort. The proportion of the GAF workers this represents is unknown and, therefore, it is not possible to make any assumptions about the representativeness of workers from the GAF period.

From the work with Mattel it should be feasible to have the complete cohort of workers who were employed at the View-Master plant during the time when TCE ceased to be used on site. Thus the TCE exposure among this group of workers would be limited to the drinking water and would not be complicated by other exposures to the chemical. ODHS anticipates that the completeness of the Mattel period cohort (1981-1998) can be verified, and the employment histories of individual workers reconstructed, using IRS records. Efforts by Mattel and IRS to coordinate this effort are ongoing. ODHS anticipates that this will be completed in Summer of 2004.

ODHS anticipates that the completeness of the GAF period cohort (1951-1980) will ultimately remain unverifiable, for the reasons stated. Nevertheless, a large number (n>6,857) of GAF workers have been identified. While ODHS cannot estimate the representativeness of these GAF workers as compared to the complete GAF period cohort, this group of former workers should be considered for inclusion in the proposed epidemiologic studies, as the large number of former workers could yield useful information about their exposure experience. In addition, including this group of workers in the health studies may make it possible to observe whether a portion of this population had actually been employed at the plant prior to the time when the contamination reached the aquifer and was present in the drinking water.

IV.B. Questionnaire Development

In February 2002, ODHS contracted with Jan Semenza, Ph.D., an epidemiological researcher at Portland State University, to develop a questionnaire for an occupational cohort study of former View-Master workers. The deliverable products of the contract were as follows: 1) the final survey instrument in English for the Mattel-Tyco TCE contamination project and 2) documentation about the development and the method of administration of the Mattel-Tyco questionnaire, including sources of questions and reasons for choosing the exact method of survey administration. A partial draft survey was developed, but not completed due to differences in understanding of what needed to be included in the instrument.

In January 2003, ODHS staff met with the head of the TCE Subregistry at ATSDR in Atlanta, GA. We were encouraged to base the survey instrument on the work that has been done by ATSDR on the populations in the TCE Subregistry to promote data comparability. ATSDR has provided ODHS with a copy of the survey instruments used. ODHS will incorporate the questions on the survey instrument for this population. ODHS will need to add additional questions about workplace tasks, duties and exposures, along with questions about possible prior and subsequent occupational exposures. Finally, ODHS will work with the View-Master CAG to involve former workers in the development of these questions.

IV.C. Stakeholder Involvement

C.1. Public Availability Sessions and Follow-up Q&A Report

ODHS held two public availability sessions on January 28, 2003 to discuss the findings of the Health Consultation Report, and to gather the questions and concerns of former workers and their families. Representatives from ATSDR, ODHS, as well as four other state and local agencies responded to questions from more than 300 former workers and concerned citizens. In a multi-agency cooperative effort, ODHS compiled a follow-up report that provided detailed answers to over 150 questions gathered at the public

meetings. This report was made available in public locations and posted to the ODHS web page (See IV.C.5. Website Information).

C.2. Formation of the Community Advisory Group

ODHS announced the formation of a Community Advisory Group (CAG) during the public availability sessions on January 28, 2003. The purpose of the CAG is to provide a forum where former workers can come together to get their questions addressed either by ODHS or other resources. It is also a way for ODHS to share information with the community, and to gather worker input for the development of the proposed health study. ODHS convened the first meeting of the CAG on April 24, 2003, and the CAG has met once per month thereafter. A technical advisory group at Oregon State University called Technical Outreach Services to Communities (TOSC) provided support for the View-Master CAG to have a professional facilitator take them through a process where they developed their own mission and operational bylaws. Participation in the CAG includes former plant workers, their relatives, and members of three citizen groups with interest in the groundwater contamination and the health concerns of former workers and their families (these groups include the Oregon Center for Environmental Health, Environmental Justice Action Group, and Victims of TCE Exposure). ODHS continues to arrange for meeting space at the Portland State Office Building for the CAG meetings. The CAG is exploring other possible meeting venues for future meetings.

The View-Master CAG has expressed strong interest in serving in an advisory capacity in the development of any study protocol. They are looking for ways to obtain technical consultation assistance from independent technical/scientific experts who would be able to translate the technical information for the members and communicate their interests regarding the study design issues.

C.3. Mattel Corporation

ODHS continues to meet with Mattel management on a monthly basis by phone or in person to coordinate the release of personnel and tax documents to ODHS. In December 2002, Mattel delivered 17 boxes of historic personnel files for ODHS to review. While the files contain information about aspects of the operation of the View-Master factory, there were no formal records on former employees such as tax records, pension records or related data that would help in the reconstruction of the cohort of former workers. Mattel continues to deliver quarterly updates of the employee database that contain changes in name, vital status and mailing address information.

In September 2002, ODHS provided Mattel with updated information about ODHS's activities. Mattel included the ODHS information in a mass mailing to the list of former employees that was sent in October 2002. In November 2003, Mattel requested a meeting between ODHS and Mattel that included a senior vice president of the corporation, the Oregon manager for Mattel, along with three technical/scientific consultants hired to advise Mattel. The consultants included two epidemiologists from academia (Jack Mandel, Ph.D. from Emory University and Michael Kelsh Ph.D. from the

University of California, Los Angeles and Exponent Consulting) and a toxicologist (Lisa Yost, MPH from Exponent Consulting). The purpose of the meeting was for Mattel to inquire about the methods ODHS intends to recommend for the public health studies to evaluate the possible health impacts from the TCE exposure among former workers. The outcome of this meeting included a commitment by Mattel to continue negotiations with the IRS to confirm the Mattel period cohort of workers and a request that ODHS keep their epidemiologic consultants informed as recommended study methods are developed.

C.4. Media Coverage of View-Master Health Issues

Print, television and radio media have continued to give extensive and frequent coverage to the health issues surrounding the former workers at the View-Master plant. The media readily carries announcements from ODHS regarding public meetings and other releases of information about View-Master. They have provided good coverage of the public availability session and View-Master CAG meetings, as well as the findings of the public health consultation report prepared by ODHS. As a result of the media coverage, ODHS receives calls, letters or email messages from former workers who have not been on the mailing list and wish to learn more about how they can be involved. These individuals are added to the data list and invited to participate in the View-Master CAG.

C.5. Web Site Information

ODHS developed web pages on the agency web site (<http://www.dhs.state.or.us/publichealth/eoe/viewmaster/index.cfm>) that provide information about the View-Master factory and efforts to develop the human health study. Copies of reports, frequently asked questions, press releases and links to other related sites are posted on the web site and are updated regularly.

C.6. Congressional Interest in Worker Health Issues

Members of the Oregon Congressional Delegation and state legislators have demonstrated an ongoing interest in tracking developments of the feasibility evaluation. ODHS responds to periodic inquiries about the View-Master workers from both state and national elected officials from Oregon. ODHS has attended in-person meetings with officials and their assistants to provide up-to-date information about the progress of the investigation. The two Senators and the Representative from Beaverton, Oregon submitted a letter to Dr. Julie Gerberding (CDC Director/ATSDR Administrator) in September 2003 asking that CDC and ATSDR support the formal health studies for the View-Master population.

C.7. Evaluation of Community Involvement Efforts

ODHS has been successful in cultivating and maintaining good communications and working relationships with both former workers and with the Mattel Corporation. However, because of the highly emotional nature of this site there are varying levels of trust in the intentions of ODHS among former workers and advocacy groups.

Nevertheless, community interest in the exposed population remains high. Public availability sessions have been attended by large numbers of former workers and other interested parties. The View-Master CAG was established and continues to function as an independent forum for worker concerns. ODHS foresees a continual need to work directly with the CAG to further develop data collection instruments and procedures for the proposed epidemiologic studies and to build public trust. ODHS continues to maintain regular communication with Mattel officials on a variety of topics related to the development of the cohort of former workers and issues related to study design. The media continue to provide ongoing coverage of issues related to the former View-Master site and to health concerns of the former workers, and elected officials are tracking progress of our efforts.

IV.D. Additional Project-related Activities

ODHS produced a public health consultation report evaluating known information about the View-Master site. The draft of the public health consultation report was released for public comment in January 2003. Following an extended comment period and incorporation of public input, the final report was released in Fall 2003. In May 2003 ODHS developed an initial conceptual protocol that was shared with ATSDR for comments. ODHS prepared and conducted several formal presentations on worker exposure to TCE in drinking water at the View-Master factory. These included the monthly scientific seminar at ATSDR Headquarters in January 2003, the National Environmental Health Association meeting in Reno, Nevada in June 2003, as well as presentations at the Western Regional Epidemiology Network meeting in May 2002, and to Portland State University School of Public Health, Oregon Health and Sciences University Department of Preventive Medicine and managers of the Oregon Department of Environmental Quality. Information about the drinking water contamination was also presented as part of the In Harm's Way Conference sponsored by the National Physicians for Social Responsibility.

IV.E. Mortality Study

E.1. Summary

As part of the View-Master Public Health Consultation report (12), ODHS presented findings from a preliminary proportionate mortality ratio (PMR) analysis for deaths among former View-Master employees during the years 1995-2001. The preliminary analysis reported that compared with the general Oregon population, the proportions of deaths among the View-Master employees were 2.94 times greater for kidney cancer and 2.10 times greater for pancreatic cancer. However, this analysis did not adjust for age or gender. In order to improve upon this initial mortality analysis and to determine the need for and feasibility of an epidemiological study of worker exposure to TCE at the factory, we conducted an additional mortality analysis, adjusting for age and gender.

ODHS compared the distribution of demographic characteristics among decedents in the View-Master workforce with the decedents in the general Oregon population. ODHS compared the causes of death, adjusted for age and gender, between the two populations in a proportional mortality ratio (PMR) analysis. The major findings of the mortality investigation are summarized here:

- ODHS identified differences between the populations in several demographic characteristics, specifically age, gender, marital status, and education.
- The results of the PMR analysis indicate that among the factory's former employees, there were more deaths from cancers of the kidney and gallbladder/extrahepatic bile duct, but fewer deaths from cancers of the liver/intrahepatic bile duct and lympho-hematopoietic cancers, than would be expected if there were no differences between View-Master workers and the general Oregon population.
- The excess in deaths from kidney cancer was observed mostly among women, and the excess in deaths from gallbladder/extrahepatic bile duct was seen only in men.

E.2. Data Acquisition

E.2.1. Data acquired by ATSDR

In August 2001, Mattel provided to ATSDR a list of the names and social security numbers (SSNs) of approximately 13,000 former plant employees. Through a separate agreement in May 2002, Mattel provided to ODHS an updated version of that same list. The updates included additional names and address changes, as well as additional or revised information about employment histories. Mattel has provided quarterly updates to the employee list, pursuant to the agreement with ODHS. ODHS used the version of the employee list that Mattel submitted in November 2002 to conduct a search for decedents in the Oregon death database.

ATSDR contracted with the Oak Ridge Institute for Science and Education (ORISE) to append the employee list with mortality data. The methods for acquiring the data are summarized as follows:

- 1) ORISE updated the list of employees with date of birth information by searching the Pension Benefits Index (PBI), matching names and SSNs. The PBI data search identified decedents and their dates of death, and it yielded a subset of the original employee list that included only the decedents.
- 2) ORISE submitted the list of decedents, updated with date of birth information, to the National Death Index-Plus (NDI) to append the list with cause-of-death information.

It would not have been possible to match the Mattel employee list directly to NDI, because the employee list contained insufficient information to fulfill the requirements for acquiring data from NDI. It was necessary for ORISE to identify the list of known decedents and their dates of birth in PBI (step 1), in order to request further data from NDI (step 2). The reason for this is that although NDI can append the data with information on cause, date, and state of death, NDI only matches information that the user submits. As a consequence, data on gender and race/ethnicity were neither matched nor supplied by NDI, because PBI did not supply information on those variables.

Using the list of decedents obtained from PBI, ORISE conducted a search for causes of death and underlying conditions by matching the decedents with NDI-Plus. The NDI maintains records from all deaths recorded in each state. When ORISE requested data in 2001, the NDI contained information about deaths that occurred during the years 1979 through 2000. In addition to identifying deaths, this service returned the following information for decedents: cause(s) of death, date of death, state of death, and death certificate number. According to ATSDR, it is expected that this service is able to capture 92-98% of all true deaths in the cohort.

ORISE submitted a file containing information about 849 individuals with dates of death between 1/1/1979 and 12/31/2000 to NDI for matching against its database. Possible matches were returned for 843 workers; no matches were returned for the remaining 6 workers. The possible matches were reviewed using an electronic algorithm to select the best match. The electronic algorithm identified an NDI record for 818 workers. For the remaining 25 workers, all NDI possible matches were manually evaluated to select a good match. Among these 25, an NDI record was chosen for 14, no record was chosen for 9, and a bad SSN/name combination was identified for 2. For these 2 workers, no additional effort can be made to retrieve a death certificate (DC) since there is no way to determine their vital status. For the 832 workers with a match to an NDI record, the NDI Plus record containing cause of death data was the chosen for 829.

E.2.2. Data acquired by ODHS

In August 2002, ATSDR supplied ODHS with two datasets containing information about former View-Master workers who have died. One dataset contained the results of the PBI search for decedents, and the other dataset contained additional information about those decedents from NDI-Plus.

The PBI dataset identified 973 people who died during the years 1951 through 2001. The PBI data search provided information about dates of birth and death, and some information about state of residence. The PBI search did not provide information about demographic characteristics other than age.

The NDI-Plus dataset provided information about 849 people who died during the years 1979-2000. The NDI-Plus data search provided additional information about state of residence, NDI death certificate number, and underlying cause of death. The NDI-Plus

data search did not provide information about gender or other demographic characteristics.

In the original objectives for the feasibility investigation, ODHS proposed to collaborate with ATSDR in acquiring copies of death certificates, and in requesting copies of out-of-state certificates for those who died outside of Oregon. In November 2002, ATSDR informed ODHS ATSDR would not be able to assist with ODHS in further data collection efforts for the mortality study. As a result, ODHS ceased its efforts to obtain death certificates accordingly.

ODHS independently searched the Oregon death database for former View-Master workers who died between 1989 and 2001. The Oregon death database contains electronic information about deaths since 1989 among residents of Oregon and non-residents who died in Oregon. ODHS conducted the matching based on name and SSN, using the updated employee list that Mattel supplied ODHS in November 2002.

The match between the Mattel list and the Oregon death database yielded 616 decedents who died in 1989-2001. ODHS subsequently matched this list with the PBI and NDI data. The total deaths from the combined data sources numbered 1036. [Table 2](#) provides the numbers of deaths among former View-Master workers by year and by data source (PBI, NDI, Oregon Vital Records, and all data sources combined), and also by availability of age, gender, and cause of death. The completeness of cause-of-death information over time is shown graphically in [Figure 3](#).

A comparison of the ODHS search for View-Master decedents in the Oregon death database with the ORISE search for View-Master decedents in the PBI showed that the Oregon death data yielded 63 more deaths in 1989-2001 than did the PBI search. [Table 3](#) shows the distribution of these 63 additional deaths by year.

The NDI supplied the causes of death for 829 decedents in 1979-2000. The Oregon data supplied causes of death for 616 decedents in 1989-2001. 511 decedents occurred in both the NDI and Oregon datasets during overlapping years (1989-2000). The code for cause of death differed between the NDI and Oregon databases for 24 View-Master workers who died in 1989-1996. The NDI cause of death was used for analysis when the cause of death differed between the two data sources.

The dates of birth differed between the Oregon death data and the PBI data by 366 days or less among 26 decedents; for 25 of these 26, the underlying cause of death was the same between the NDI and the Oregon databases. The date of death differed by 239 days or less among 101 decedents; for 93 of these 101, the underlying cause of death was the same between the NDI and the Oregon databases. In such cases, the dates of birth and death supplied by the PBI were used to calculate age, and the NDI cause of death was used as the default. Age at death was grouped into 5-year categories for analysis.

E.3. Data Analysis

E.3.1. Demographic Characteristics

ODHS compared the distributions of the demographic characteristics between the View-Master and general Oregon populations. Tables [4](#), [5](#), and [6](#) show the distributions of the characteristics in both populations. [Table 6](#) provides *P*-values to indicate whether the distributions of demographic characteristics differ between the two populations to a statistically significant degree.

ODHS derived the variables for gender, race, Hispanic ethnicity, marital status, and education from the Oregon death database. The availability of information about these characteristics among View-Master workers therefore depended upon whether a decedent was found in the Oregon death database, as neither PBI nor NDI-Plus supplied information about these variables.

ODHS used the coding assigned by the Oregon Vital Records Office for interpreting the variables for race, Hispanic ethnicity, and marital status. ODHS used age information from the Oregon database only when the dates of birth and death were not supplied by the PBI data. Age was then grouped into 5-year categories.

Gender

The Oregon vital records database contained complete information about gender for all deaths in 1989-2001. By contrast, gender information was missing for 19.3% of the View-Master workers who died during those years.

According to Mattel, women constituted about 60% of the workforce throughout the factory's operation. In this analysis, females constituted nearly 70% of the View-Master decedents for whom gender was available, compared with 49.2% of all decedents in Oregon. [Table 5](#) shows the distribution of gender among the decedents in the View-Master and general Oregon populations.

Age

The distribution of age at death differed greatly between former View-Master workers and the general Oregon population. [Table 4](#) and [Figures 4](#) and [5](#) show the distribution of age at death between the two populations. People aged 85 and older constituted 26% of all decedents in Oregon, the largest proportion of deaths in Oregon during the years 1989-2001. By contrast, people aged 85 and older constituted only 4.6% of the deaths in the View-Master population during those years.²

² The observed differences in the age distribution of the deceased do not indicate whether lifespan differs between the View-Master workforce and the general Oregon population. Such a comparison would require information that is currently unavailable about the entire cohort of former View-Master workers, including all who are still living.

Ethnicity

Most people in both the Oregon and View-Master populations were non-Hispanic Caucasians (see [Table 6](#)). There were proportionally more African Americans in the View-Master workforce than in the general Oregon population. Relative to their representation in the general Oregon population, Asian/Pacific Islanders made up a significant proportion of the View-Master workforce among males, but not among females.

Education Level

Level of education is recorded in the Oregon death database as the highest number of years of schooling attained by the decedent. ODHS grouped years of schooling into three categories: 8 years or less, 9-12 years, and 13+ years. View-Master workers differed significantly from the general Oregon population in their level of education (see [Table 6](#)). Male View-Master workers tended to have more years of schooling overall than did males in the general Oregon population. By contrast, proportionally fewer female View-Master workers had 13+ years of school compared with their Oregon counterparts. Male View-Master workers tended to be more highly educated than their female co-workers; 35.5% of males had 13+ years of school compared with only 16.7% of females. This difference suggests that in proportion to their representation in the workforce, men might have been more likely than women to hold jobs of higher rank or pay status.

Marital Status

Female View-Master workers were significantly more likely, and male View-Master workers less likely, to have been married at the time of death compared with their respective counterparts in the general Oregon population (see [Table 6](#)). View-Master workers were less likely to have been widowed compared with their Oregon counterparts, an observation that may be explained by the greater representation of decedents aged 85+ in the general Oregon population.

Residency

The state of death was known among 983 (95%) of the 1036 deaths among View-Master workers. Most (78%) View-Master decedents were residents of Oregon. The next largest proportions were residents of Washington and California: 5.3% and 4.2%, respectively. [Table 7](#) shows the distribution of deaths by state of residence among all View-Master decedents in 1952-2001. [Table 7](#) also provides the state of residence among only the View-Master decedents who were found in the Oregon vital records database in 1989-2001.

E.3.2. Death Data

ODHS compared the deaths among former View-Master workers with all deaths in Oregon during the years 1989-2001. [Table 8](#) shows the total deaths per year among former View-Master workers and the general Oregon population. These years were selected for review because the Oregon death database contains electronic information

about deaths among residents of Oregon and non-residents who died in Oregon since 1989.

ODHS grouped the causes of death among View-Master workers and the Oregon population according to Surveillance Epidemiology End Results (SEER) cause-of-death recodes. SEER has defined major site groups based on the International Classification of Diseases version 9 for years 1979-1998, and version 10 for 1999+. To recode specific causes for which SEER recodes were not available, ODHS used the ICD-9 and ICD-10 groupings assigned by the Oregon Vital Records Office for compiling vital statistics reports. [Table 9](#) lists the ICD-9 and ICD-10 recoding scheme that ODHS used for analyzing causes of death.

[Table 10](#) summarizes the causes of death among all View-Master workers who died during 1979-2001. ODHS could not compare the entire mortality dataset on View-Master decedents with the causes of death in the general population, because comparable data for all deaths in Oregon is not electronically available prior to 1989. ODHS therefore compared the causes of death among View-Master workers and the general Oregon population for a subset of years (1989-2001) in an analysis of proportionate mortality, as discussed in the following section.

The youngest death among male View-Master workers occurred in the age group 15-19. The youngest death among female View-Master workers occurred in the age group 20-24. Analyses of additional demographic characteristics ([Table 6](#)) excluded deaths at ages younger than 15 among Oregon males, and younger than 20 among Oregon females.

E.4. Proportionate Mortality Analysis

E.4.1. Methods

A commonly used measure of relative mortality in studies of occupational and other hazards is the “observed-to-expected ratio.” This is the ratio of observed deaths among exposed people to a hypothetical estimate of expected deaths, based on the experience of a reference (or non-exposed) population. Computing the expected number of deaths generally requires information about the size of the population at risk. Specifically, one must discern the number of person-years of follow-up on the workers under study.

When information about the entire at-risk population is unavailable, a common practice is to compute the proportional mortality ratio (PMR). Such a computation considers deceased subjects only. The premise of the PMR analysis is as follows:

If an exposure causes a specific fatal illness, there should be a greater proportion of deaths from that illness among those who had been exposed, than among other decedents who had not been exposed. The PMR can be interpreted as the observed-to-expected ratio only if one assumes that the total death rates for the exposed and the reference (non-exposed) populations are equal (13).

The size and person-years of the entire View-Master worker population are not yet known. ODHS therefore conducted a PMR analysis of existing mortality information, comparing the causes of death among former View-Master workers against the causes of death in the general Oregon population, with adjustment for age and gender. The analysis included deaths that occurred during the years 1989 through 2001, and excluded deaths for which information about age and gender were not available.

ODHS calculated the expected number of deaths for each cause of death, based on the experience of all decedents in Oregon. The expected numbers of deaths were computed as follows:

- Multiply each cause of death in the worker cohort by the proportion of deaths by that same cause in the general Oregon population.
- Multiply all deaths that occurred within a given 5-year age group of the specified gender, by the total deaths that occurred among View-Master workers within that gender and age group.
- Sum the expected values among all age strata within the specified gender to display the total deaths from a selected cause that would be expected in the View-Master population
- Calculate the PMR values by computing the ratio of the sum of observed deaths to the sum of expected deaths, for each cause of death. [Table 11](#) shows the numbers of observed and expected deaths for selected causes of death.

ODHS determined the statistical significance of the observed to expected (PMR) ratios, based on the Poisson distribution.³ For each cause, ODHS computed 95% and 99% confidence intervals around the observed number of deaths, using confidence intervals for the Poisson distribution.⁴ ODHS considered the PMR estimate for a given cause to be statistically significant if the expected number of deaths did not fall within the confidence interval for observed values. [Table 11](#) indicates the statistical significance of the PMR results.

The Poisson distribution is usually associated with rare events occurring over time. It assumes that the deaths of interest occur (1) independently of one another and (2) at a constant rate throughout the study. (14) To assess whether the assumptions for the Poisson distribution are acceptable for this analysis, ODHS examined the relationship between the mean and variance in the number of deaths per year among View-Master workers, for each cause of death. [Table 12](#) shows the range, mean, and variance in the number of deaths per year from each cause. The ratio of variance to mean ranged from 0.68 to 2.09 among females, and 0.83 to 2.40 among males. ODHS concluded that the means and variances were reasonably similar overall, and that it would be appropriate to assume that the Poisson distribution applies to the existing data.

³ Because some expected values were less than 1.0, the chi-square test could not be used. ODHS therefore based the statistical significance on the Poisson statistic rather than the chi-square test statistic.

⁴ To compute PMR values and Poisson confidence intervals, ODHS used the statistical software packages SPSS and STATA, respectively.

E.4.2. Results

As stated earlier, ODHS presented a preliminary PMR analysis of the years 1995-2001 that did not adjust for age and gender. (12) The preliminary analysis found that compared with the general Oregon population the proportions of deaths among the View-Master workers were 2.94 times greater for kidney cancer and 2.10 times greater for pancreatic cancer.

ODHS subsequently conducted additional analyses of the mortality data, adjusting for age and gender for the years 1989-2001. These analyses compared the distribution of demographic characteristics among decedents in the View-Master workforce with the decedents in the general Oregon population for the same time period. The full methods and findings of these mortality analyses are provided here. Some of the key findings include the following:

- Deaths from all cancers combined were not elevated among either men or women in the View-Master workforce.
- The number of deaths from kidney cancer among males was 2.76 times greater than expected, but the excess was not statistically significant (ns).
- ***Among females, the number of deaths from kidney cancer exceeded more than six times the expected number (PMR 6.21, P < 0.01).***
- ***Deaths from two types of cancers of the digestive system were significantly elevated among men; specifically, cancers of the gallbladder and extrahepatic bile duct (PMR 8.41, P < 0.05).***
- Stomach cancer (PMR 2.79) and pancreatic cancer (PMR 2.29) were also elevated among men, but the level was not significant. Among women, deaths from pancreatic cancer were slightly elevated but to a non-significant degree (PMR 1.61, ns)
- Fewer than expected deaths from lymphatic and hematopoietic cancers occurred among both men and women in the View-Master workforce.
- The number of men who died from cancer of the liver and intrahepatic bile duct was not excessive.

E.4.3. Limitations of the Mortality Analysis

This analysis has critical limitations that prevent conclusive interpretation of the PMR findings.

Lack of exposure information

The assumption of the PMR analysis is that members of the View-Master workforce, as a group, had more oral exposure to TCE than did the general Oregon population. Having worked for any length of time at the View-Master factory, and being included on Mattel's employee list, serve as a surrogate for TCE exposure of unspecified dose and duration. The analysis does not account for variations in length of employment, calendar years of employment, occupational exposures, water consumption, or historical levels of TCE in the supply well, so it cannot account for the differences in cumulative TCE exposures that would have resulted from these variations. The lack of actual exposure information is a critical limitation of this analysis.

Incomplete data

The current list of employees is known to be incomplete. ODHS is actively negotiating with Mattel to receive IRS records that would identify all those employed during the Mattel Period.

The gender of the deceased was unavailable for a substantial proportion (19.3%) of View-Master deaths that occurred during the period of study (1989-2001). [Table 13](#) shows the causes of death among 147 decedents excluded from the PMR analysis because of missing gender. There were no deaths from kidney cancer among these 147 workers, and there were proportionally fewer deaths from cancers of the pancreas and other digestive organs, compared with View-Master workers whose gender was known. Therefore, the PMR results for cancers of the kidney and digestive organs may be inflated as a consequence of the exclusion of those decedents from the analysis. The PMR findings and their statistical significance would likely be attenuated for these cancers, if complete gender information was available.

By matching the Mattel employee list with the Oregon vital records database, ODHS found 63 more deaths in 1989-2001 than ORISE found by searching for decedents in the PBI database (see [Table 3](#)). ODHS used an updated version of the employee list. This version might have accounted for slightly more former workers than the list that ORISE used, but it is unlikely that those additional entries would completely explain the 63 additional deaths found in Oregon's vital records. Moreover, a sharp increase in the number of deaths in 1993 (see [Figure 3](#)) raises further questions about whether all deaths are completely represented in the PBI, and whether the completeness of the PBI varies with calendar year. Independently matching the employee list to the Oregon death database did help to rectify deficiencies in the PBI for deaths that occurred in Oregon, but it is not known whether additional deaths in other states remain missing. To better assess the quality of the current mortality data, it would be necessary to investigate the methods of data collection that PBI uses, and whether those methods have changed over time.

Cause information for deaths outside of Oregon was altogether lacking in 2001, because NDI-Plus data were available only through 2000 at the time the data were gathered. View-Master decedents who were included in the PMR analysis were more

likely to have been Oregon residents compared with those who were excluded, because the Oregon death database was the only data source that supplied gender information (see [Tables 2](#) and [7](#)). The exclusion of non-Oregon residents from a comparison of View-Master workers with the general Oregon population may have improved the comparability of the two populations in the analysis. This advantage is outweighed, however, by the loss of information from workers who were excluded from the analysis.

For 24 View-Master workers, the cause of death differed between the Oregon vital records database and NDI, though the decedents' names and social security numbers were the same between the two data sources. To rectify inconsistencies in cause-of-death information, as well as to rectify the deficiencies in gender and other demographic information, ODHS recommends that future investigations of mortality among View-Master workers rely on copies of death certificates for all decedents.

Inherent limitations of the PMR method

An inherent weakness of PMR studies is that they reveal nothing about the overall force of mortality. (15) Proportional excess in one cause of death may indicate either excess in the rate for that cause of death, or a deficit in the rates of death from other causes.

The results of this PMR analysis do not show how the survival experience of former View-Master employees compares with those of the general public. Such an assessment would involve the comparison of rates, which would require information about the entire cohort of former View-Master workers, including all who are still living. To fully assess whether mortality from specific causes differs between View-Master workers and the general population, ODHS recommends conducting an analysis of standardized mortality rates (SMR). An SMR study that would take into account the size of the entire worker population and the number of person-years of follow-up would overcome the limitations and clarify the findings of the PMR analysis.

The computation of rates for an SMR study would require, at a minimum, the age and gender of all members of the View-Master workforce, both living and deceased. Such information may be available from credit bureaus or other private sector databases. The lack of exposure data would remain a limitation, however, if the SMR study did not gather information from former workers about their employment histories or occupational exposures.

Differences between populations

The comparison of demographic characteristics suggests that there is significant variation between View-Master workers and the general Oregon population, as observed in such aspects as age, gender, education and marital status. The ways in which the two populations differ may be independently associated with disease risk and have no relation to TCE exposure. The PMR analysis is limited by the lack of adjustment for demographic characteristics other than age and gender.

The comparability between the two populations may be further reduced by the “healthy worker bias.” This concept usually refers to a tendency for any particular employed population to have lower mortality, from all causes combined, than the general population. This phenomenon is thought to result from the selective entry of healthy persons into the workforce, and early removal of unhealthy persons from the workforce. The healthy worker effect can be minimized if the use of the general population as a comparison group is replaced by the use of an occupational population with comparable job entry and exit factors. (15,16) In the recommendations of the report, ODHS has included the use of an occupational referent population as a possible comparison group for the View-Master cohort.

While both PMR analyses identified higher than expected percentages of deaths from causes that have been associated with TCE exposure, there were also lower than expected mortality outcomes from other causes that have also been linked with TCE exposure in the literature. There are inherent limitations to the PMR analysis that makes it useful only as a screening tool to assess whether further and more in depth investigation is warranted.

The lack of exposure information is a critical limitation of the mortality analyses. The PMR analysis does not account for variations in length of employment, calendar years of employment, occupational exposures, water consumption, or historical levels of TCE in the supply well, so it cannot account for the differences in cumulative TCE exposures that would have resulted from these variations. This limitation underscores the importance of gathering the critical information about exposures from the surviving relatives of the decedents.

Another limitation of this analysis is that there is no basis for comparison of the View-Master population to the general Oregon population or other occupational cohorts with respect to other risk factors for disease. Again, more information is needed regarding all members of the View-Master population.

According to Mattel, women constituted about 60% of the workforce throughout the factory’s operation. Women in the U.S. have a lower baseline risk than men do for developing cancers of the kidney, liver, pancreas, and lympho-hematopoietic system (17). The mortality from specific cancers should therefore be analyzed separately among men and women in the View-Master workforce. Stratification by gender was limited in this analysis, however, because the existing data on deceased View-Master workers contains incomplete gender information. This presents a limitation to the analysis.

The results of the PMR analysis look only at deaths and therefore do not show how the overall survival rates of former View-Master employees compare with those of the general public. To compute accurate observed-to-expected mortality ratios would require the identification and follow-up of the entire cohort of former View-Master workers, including all who are still living.

The PMR analysis conducted during the feasibility investigation identified higher than expected proportions of deaths that need further evaluation to fully understand their significance in relation to the exposures experienced by this worker population. The next level of analysis regarding causes of death would be the standardized mortality ratio (SMR) that would require information about the complete population at risk for death along with exposure information that would be generated through a retrospective cohort interview study.

E.4.4 Conclusions

ODHS conducted a PMR analysis because the information about the population at risk required for an SMR analysis is not currently available. The gaps in the existing mortality data are excessive and prevent conclusive interpretation of the PMR findings. Despite inherent limitations, the PMR method can provide leads about possible associations that may be worth pursuing. The PMR analysis identified excess in deaths from kidney cancer among former View-Master workers, but the degree of excess may be overestimated because of missing data. Elevated PMR's were observed in this analysis for cancers of the digestive system among men, but not among women.

In conclusion, the findings and limitations of the PMR analysis underscore the need for more thorough investigation of the impact of oral TCE exposure on the health of former workers of the View-Master factory. ODHS recommends that a study of standardized mortality rates (SMR) be conducted to help clarify the findings and overcome the inherent limitations of the PMR method.

V. CONCLUSIONS OF THE FEASIBILITY INVESTIGATION

The following is a summary of the conclusions of the feasibility investigation:

- The levels of TCE were high in the contaminated aquifer that was used to supply drinking water to the workers at the plant;
- The potentially exposed population is very large (potentially up to 25,000) and a large portion of this population is known;
- The nature of the exposure was essentially confined to one primary contaminant (TCE) accompanied by the presence of much lower levels of a second and related contaminant (PCE);
- Since 1981 there was a single exposure pathway (oral ingestion of contaminated drinking water); and
- The exposure and follow-up time have been unusually protracted (ODEQ estimated that the contamination likely reached the well water by the mid- to late-1960s).

This unique combination of factors supports the necessity for in-depth health studies of the population that worked at this site. Further investigation of this exposed population would advance the existing medical and scientific knowledge about the impact of TCE on human health. Completion of the fate and transport analysis would more precisely pinpoint when the well water became contaminated and estimate how contamination levels likely changed over time. ODHS and ATSDR considers the View-Master factory site and the exposures to workers to constitute a past public health hazard. Therefore, the Oregon Department of Human Services perceives a pressing need for more thorough investigation of the impact of this hazard on the exposed population.

Reconstruction of the subcohort of workers who were employed during the Mattel period (1981-1998) is believed by Mattel to be complete and is in the process of being confirmed by the request for IRS data by Mattel Corporation. The 6,857 names of workers from the GAF period represents between 38% and 52% of the complete subcohort who worked at the plant between 1951 – 1981. While it is unlikely that the remainder of this cohort could be easily reconstructed (because employment records are lacking and GAF corporation expressed their unwillingness to collaborate with ODHS), this group represents a substantial number of people who worked at the plant during the time that TCE was used and likely during part of the time when the drinking was contaminated.

VI. RECOMMENDATIONS

ODHS recommends that a formal public health investigation of the population of former workers at this site be conducted and it should include:

1. An environmental fate and transport assessment to confirm ODEQ's estimate of how long TCE was present in the supply well, and to provide a historical understanding of the concentration of TCE in the well over time; and
2. Epidemiological studies to record exposure information and to evaluate whether reported adverse health and reproductive outcomes among former workers and their offspring (conceived during the time of the parents' employment) are associated with TCE exposures, whether the complete mortality experience among the population of former workers who have died was associated with specific causes of death that might be reasonably associated with TCE exposure, and whether the cancer experience among this population is different from either the Oregon population or some other appropriate referent population.

Specifically, ODHS recommends the following:

1. ATSDR, or another appropriate agency, should conduct analyses of groundwater and fate transport to reconstruct the migration of the contaminant from the source areas to the production well. The information that would result from the proposed groundwater modeling analysis would provide critical exposure data for the epidemiological study. The analysis could help to establish the following:

- a. When the TCE contamination initially reached the well; and
 - b. The degree to which the concentration of TCE might have varied throughout the operation of the View-Master plant.
 - c. Knowledge about the historical levels of TCE in the well would help investigators to develop more precise classifications of exposure based on year of employment and, therefore, years of exposure. For example, having a well-defined estimate of when the plume first reached the well would enable investigators to identify an unexposed sub-cohort of the worker population.
 - d. Reducing the potential for exposure misclassification would allow for potentially more sensitive epidemiological analyses.
2. ODHS or another appropriate agency should conduct a retrospective occupational cohort interview study to evaluate reported adverse health and reproductive outcomes among former workers and determine whether they are associated with workplace TCE exposures. Specific methods could include:
- a. Identify and contact all potentially exposed persons or their next of kin, or developing a method for identifying and contacting a valid and representative sample of potentially exposed persons or their next of kin;
 - b. Collecting information about exposures, risk factors, and health outcomes by interviewing former workers or their survivors, investigating deceased former workers' causes of death, and reviewing cancer information that relates to those workers who have reported developing cancer since the time they worked at the View-Master factory;
 - c. Estimating individual cumulative TCE dose based on length of employment, calendar years of employment, types of jobs held, source of water, and amount of water consumed;
 - d. Conducting a nested case-control study of childhood health outcomes among people who were potentially exposed *in utero*; and
 - e. Comparing rates of morbidity and mortality among the former worker population to those of the general population of Oregon, an occupational referent population (Thomas, et al, 1986), or other relevant comparison groups.
3. Based on the findings of this feasibility investigation, ODHS recommends that these studies focus on the subcohort of workers that were employed during the Mattel period (1981-1998).
- a. Negotiations are in process between Mattel Corporation and the U.S. Internal Revenue Service to confirm the completeness of this group of former employees.
 - b. The advantage of studying this population (of approximately 6,468 people) is that they represent the complete group of workers who were employed after the use of TCE at the plant had ceased, and drinking contaminated water would have been the primary route of exposure.

- c. ODHS believes it would be a more effective use of resources and more time efficient to first study this smaller, but complete population. The findings of these first studies will identify whether there is the need to identify and evaluate the population from the earlier GAF period.
- d. The findings of the retrospective cohort interview study would provide needed exposure classification information for the mortality assessment, the cancer study and the evaluation of birth outcomes.
- e. The retrospective cohort interview study will also be able to evaluate and control for other risk factors such as prior or subsequent contact with TCE or related solvents in different jobs, as well as exposures to tobacco, alcohol, etc.

ODHS believes that the exposure scenario at the View-Master factory in Beaverton, Oregon represents an unusual and unique situation where a large number of workers were unknowingly exposed to high levels of essentially a single primary contaminant (TCE) for a long period of time, via a single route of ingestion exposure. This situation represents a very unfortunate exposure incident that needs to be investigated properly to learn whether and to what extent the health of this population has been impacted. The purpose of the proposed epidemiological studies is to understand the public health impact of exposure to this contamination. Accurate dose information from the fate and transport analysis, combined with the information gathered through the interview study, would render the results more meaningful to other sites in which oral TCE exposure occurred. The findings of these efforts should contribute to the general knowledge of human exposure to this commonly used solvent that is considered to be a human carcinogen and is associated with other non-cancerous health effects.

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TABLES AND FIGURES

Figure 1. Site Map

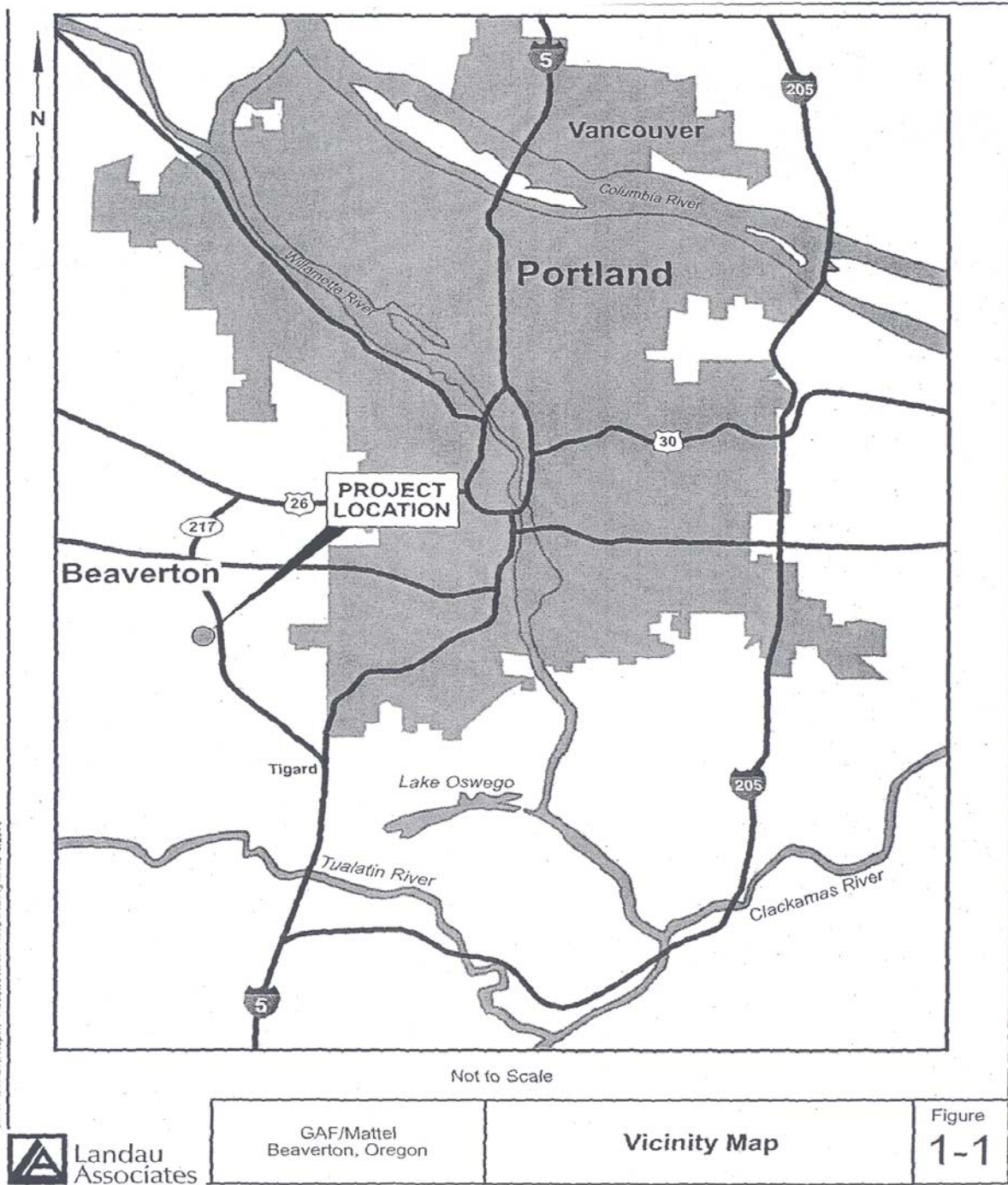


Figure 2. Title Summary

Hart Crowser
J-5737

Table 1 - Title Summary
Sawyer's/GAF/View-Master/Tyco/Mattel Operations
Beaverton, Oregon

Date	Property Ownership				Facility Operator
	Parcel 1		Parcel 2	Parcel 3	
	Northeast Corner	Current Facility			
8/2/51	Western Realty		Sylvesters & Reels (Individuals)	Sawyers Inc.	
8/9/51	Western Photo				
8/16-24/51	Various Western Photo Shareholders				
1957-1965					
10/27/66	Sawyers, Inc. (Delaware)				
10/31/66					
4/7/67	GAF Corp.			GAF Corp.	
2/21/79					
6/26/81	View-Master International Group			Southern Pacific Industrial Development Co. (then subdivided)	
2/28/83	Western Industrial Properties (and lease back)				
8/13/83	LPAWC joint venture (leases to others)				
7/17/84	Commercial Real Estate Co.	John Eyster (contract sale recorded)			
2/28/85		Cascade Square Associates			
Early 1987					
June 1989					
3/12/97	Cascade 8625 Assoc.				
April 1998		Hill Street Associates, LLC			

Notes:

1. Title information provided by Oregon Title and summarized by Davis Wright Tremaine.
2. Facility ownership based on company records and personnel correspondence.
3. Parcels shown on Figure 3.

Table 1. Volatile organic compounds in the View-Master supply well

Sample ID	Consultant	Date collected	TCE (µg/L)	Cis-1,2- DCE (µg/L)	PCE (µg/L)
Prod. Well	SECOR (2)	16 March 98	1220	15.2	34.5
Tyco 2S		24 March 98	1520	20.5	56.0
Tyco 3S		24 March 98	1390	33.0	42.3
Wellhead	Hart Crowser (3)	26 March 98	1460	14.1	38.2
B1150/SHIP		26 March 98	1670	14.7	42.4
Maximum contaminant level*			5	70	5

* U.S. Environmental Protection Agency Drinking Water Standards and Health Advisories

Table 2. Numbers of deaths among former View-Master workers by year and by data source (PBI, NDI, Oregon Vital Records), and by availability of age, gender, and cause of death

Year	PBI	NDI	Oregon Vital Records	Combined Sources	Cause Available	Age Available	Gender Available
1952	1			1		1	
1962	1			1			
1967	1			1		1	
1970	2			2		2	
1971	1			1		1	
1972	7			7		7	
1973	7			7		7	
1974	9			9		9	
1975	11			11		11	
1976	10			10		10	
1977	9			9		9	
1978	13			13		13	
1979	19	19		19	19	19	
1980	13	13		13	12	13	
1981	12	12		12	12	12	
1982	15	15		15	12	15	
1983	20	20		20	20	20	
1984	28	28		28	27	28	
1985	20	20		20	20	20	
1986	17	17		17	17	17	
1987	27	27		27	27	27	
1988	30	30		30	24	30	
1989	32	32	31	39	38	39	31
1990	29	29	26	33	33	33	26
1991	36	36	32	40	38	40	32
1992	37	37	32	39	38	39	32
1993	66	66	59	67	64	67	59
1994	61	61	50	63	63	63	50
1995	58	58	48	61	61	61	48
1996	65	65	50	67	66	67	50
1997	73	73	61	78	78	78	61
1998	61	61	51	65	64	65	51
1999	62	62	54	66	65	66	54
2000	68	68	59	74	73	74	59
2001	52		63	71	63	71	63
Total	973	849	616	1036	934	1035	616

Figure 3. Distribution of deaths and completeness of cause-of-death information among former View-Master workers, by year (1952-2001)

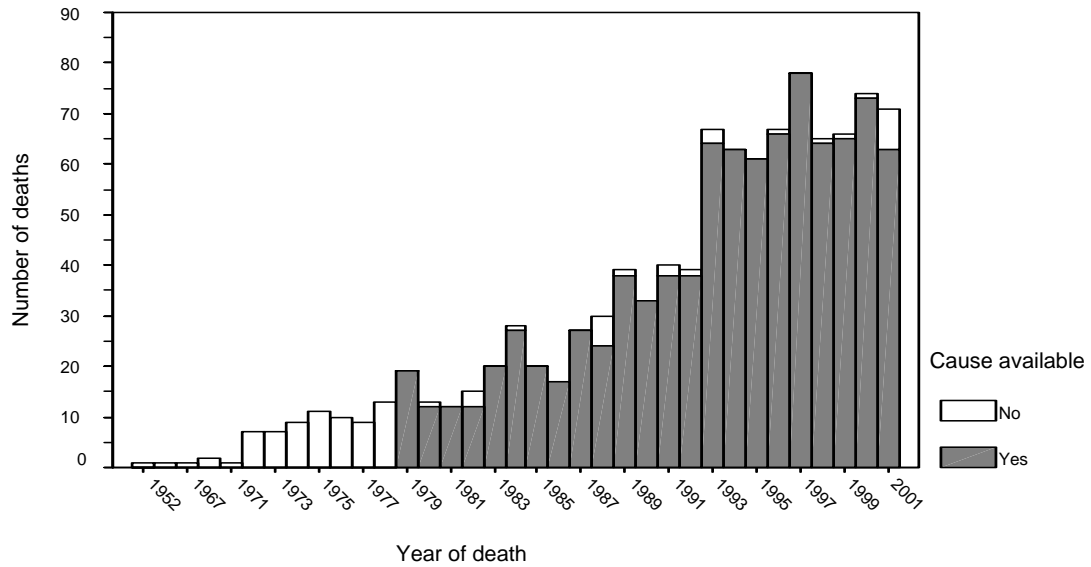


Table 3. Number of additional View-Master deaths by year (1989-2001) found in the Oregon death database but not found in PBI

Year	Deaths
1989	7
1990	4
1991	4
1992	2
1993	1
1994	2
1995	3
1996	2
1997	5
1998	4
1999	4
2000	6
2001	19
Total	63

Table 4. Distribution of deaths among former View-Master workers and the general Oregon population by age at death, 1989-2001

Age Group	View-Master workers		All deaths in Oregon	
	Number of deaths	% of Total	Number of deaths	% of Total
<1-4			4982	1.3
5-9			567	.2
10-14			775	.2
15-19	1	0.13	2253	.6
20-24	3	0.39	2746	.7
25-29	10	1.31	3025	.8
30-34	20	2.62	4024	1.1
35-39	28	3.66	5671	1.5
40-44	41	5.37	7487	2.0
45-49	55	7.20	9291	2.5
50-54	54	7.07	11615	3.1
55-59	65	8.51	14472	3.9
60-64	66	8.65	20797	5.6
65-69	87	11.40	30906	8.3
70-74	108	14.15	43083	11.6
75-79	113	14.80	54179	14.6
80-84	77	10.09	58108	15.6
85+	35	4.58	98240	26.4
Total	763	100.00	372221	100.0

Table 5. Gender distribution among View-Master decedents and all decedents in Oregon, 1989-2001

Gender	View-Master			Oregon	
	Number	Percent	Valid Percent	Number	Valid Percent
Male	186	24.4	30.2	189225	50.8
Female	430	56.3	69.8	183072	49.2
Missing	147	19.3	--	0	--
Total	763	100.0	100.0	372297	100.0

Table 6. Percent distribution of demographic characteristics among View-Master workers and all decedents in Oregon^a by gender 1989-2001

	Females			Males		
	Oregon % ^b	View- Master % ^b	P ^c	Oregon % ^b	View- Master % ^b	P ^c
Race			.001			<.001
1 White	97.4	95.8		96.7	92.5	
2 Black	1.1	3.5		1.5	3.2	
3 Native American Indian	.7	.7		.8		
4 Chinese	.2			.2		
5 Japanese	.2			.2		
8 Filipino	.1			.1		
6 Hawaiian	.0			.0		
0 Other Asian/Pacific Islander	.3			.4	4.3	
7 Other	.0			.0		
9 Unknown	.0			.0		
Hispanic			.939			.030
0 Non-Hispanic	99.2	99.8		98.5	97.8	
1 Mexican	.5	.2		1.1	1.6	
2 Puerto Rican	.0			.0		
3 Cuban	.0			.0	.5	
4 Central/South American	.1			.1		
5 Other or unspecified Hispanic	.1			.2		
9 Unknown	.0			.1		
Marital			<.001			<.001
1 Never married	4.4	5.6		9.6	15.1	
2 Married	28.0	37.9		58.6	53.8	
3 Widowed	56.1	33.3		18.0	8.1	
4 Divorced	11.3	23.3		13.3	23.1	
9 Unknown	.1			.5		
Education (years of schooling)			<.001			.001
8 or less	16.4	16.0		17.9	7.0	
9-12	53.0	66.3		49.4	55.9	
13+	27.5	16.7		29.5	35.5	
Unknown	3.0	.9		3.2	1.6	

^a Aged 15 and older among males; aged 20 and older among females.

^b Per cent of deaths in the specified population and gender category.

^c P-value, based on the χ^2 test for independence, for association of characteristic with population group.

Figure 4. Distribution of age at death among former View-Master employees, 1989-2001

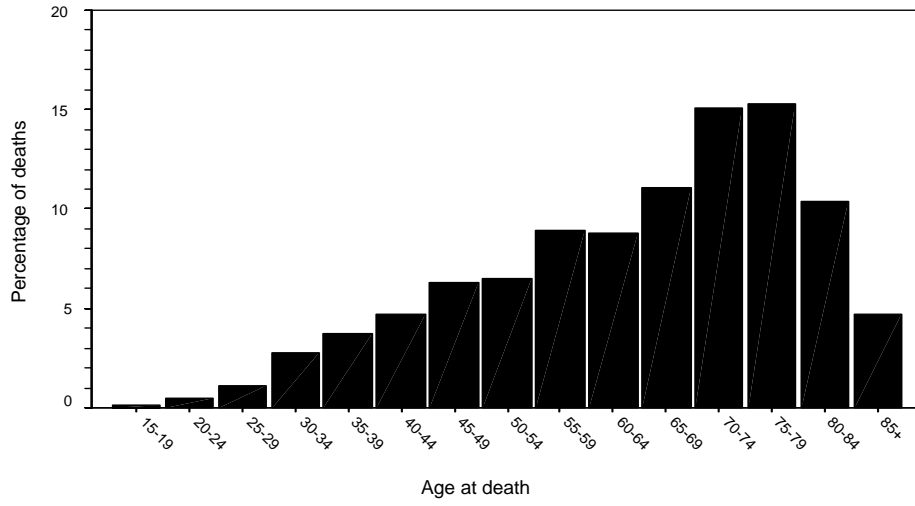


Figure 5. Distribution of age at death among all decedents in Oregon, 1989-2001

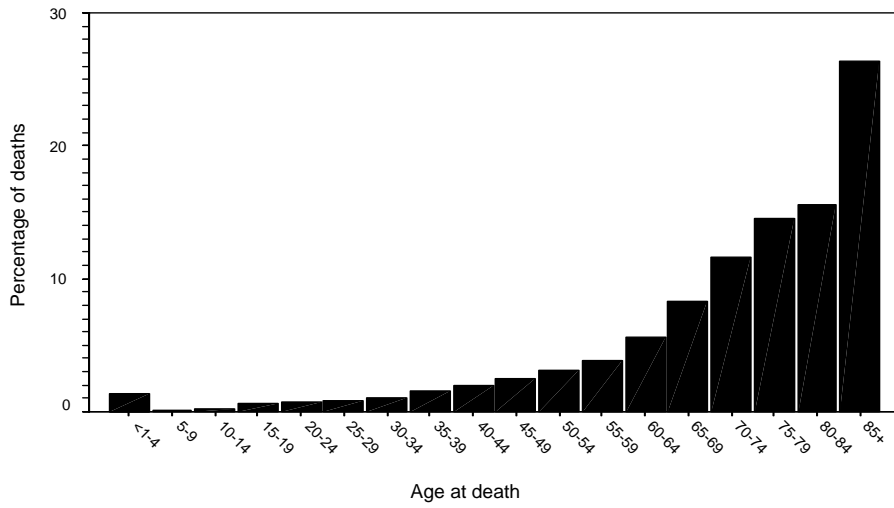


Table 7. Distribution of deaths among View-Master workers, by state of residence

State of residence	All deaths, 1952-2001		Deaths found in Oregon's Vital Records Database 1989-2001	
	Number of deaths	Percent	Number of deaths	Percent
Alabama	2	.2		
Alaska	1	.1		
Arizona	9	.9		
Arkansas	5	.5		
California	44	4.2	1	.2
Colorado	4	.4		
Florida	3	.3		
Georgia	2	.2		
Hawaii	1	.1		
Idaho	4	.4		
Illinois	3	.3		
Indiana	2	.2		
Iowa	2	.2		
Kansas	1	.1		
Massachusetts	1	.1		
Minnesota	3	.3		
Montana	1	.1		
Nebraska	2	.2		
Nevada	4	.4		
New Jersey	1	.1		
New York	4	.4		
North Carolina	1	.1		
Ohio	1	.1		
Oklahoma	2	.2		
Oregon	806	77.8	608	98.7
Puerto Rico	1	.1		
Tennessee	1	.1		
Texas	9	.9		
Utah	2	.2		
Virginia	2	.2		
Washington	55	5.3	7	1.1
Wisconsin	4	.4		
Information not available	53	5.1		
Total	1036	100.0	616	100.0

Table 8. Number of deaths per year among former View-Master workers and the general Oregon population, 1989-2001

Year	View-Master workers		All deaths in Oregon
	All deaths	Deaths found in Oregon database	
1989	39	31	25775
1990	33	26	26141
1991	40	32	25950
1992	39	32	26754
1993	67	59	28614
1994	63	50	28326
1995	61	48	29120
1996	67	50	29867
1997	78	61	29712
1998	65	51	30213
1999	66	54	30282
2000	74	59	30463
2001	71	63	31080
Total	763	616	372297

Table 9. Cause-of-death coding with ICD-9 and ICD-10 recodes

Cause	ICD9 (1989-1998)	ICD10 (1999+)
All causes of death	001-999	A00-Z99
All malignant neoplasms	140-208, 238.6	C00-C97
Digestive organs and peritoneum	150-159	C15-C26, C48, C45.1
Esophagus	150	C15
Stomach	151	C16
Small Intestine	152	C17
Colon, Rectum, and Anus	153, 154, 159.0	C18-C21, C26.0
Biliary passages and liver primary	155, 156	C22-C24
Liver and intrahepatic bile duct	150	C22
Gall bladder and other biliary	156	C23, C24
Pancreas	157	C25
Respiratory system	160-165	C30-C39, C45.0
Bronchus, trachea, lung	162	C33, C34
Breast	174, 175	C50
All uterine (women only)	179-182	C53-55
Cervix (women only)	180	C53
Other female genital organs (ovary)	183, 184	C 51, C52, C56-C58
Prostate (men only)	185	C61
Kidney, renal pelvis, ureter	189.0, 189.1, 189.2	C64-66
Bladder, other urinary organs	188, 189.3-189.9	C67, C68
All lymphatic and hematopoietic	200-208	C81-C96
Hodgkins disease	201	C81
Leukemia	204-208	C91-C95
Other lymphopoietic tissue	200, 202, 203	C82-C85, C88-C90, C96
Diabetes mellitus	250	E10-E14
All heart disease	390-398, 402, 404, 410-429	I00-I09, I11, I13, I20-I51
Ischemic heart disease	410-414	I20-I25
Cerebrovascular disease	430-438	I60-I69
Nonmalignant respiratory disease	460-519	J00-J99
Bronchitis, emphysema, asthma	490-493	J40-J42, J43, J45, 46
Emphysema	492	J43
Chronic liver disease and cirrhosis	571	K70, K73, K74
Nephritis and nephrosis	580-589	N00-N07, N17-N19, N25-N27
All external causes of death	E800-999	V01-Y89
Accidents	E800-949	V01-X59, Y85, Y86
Suicides	E950-959	X60-X84, Y87.0
Other causes of death	Remainder of deaths with known cause	Remainder of deaths with known cause
Cause not obtained in data search	Deaths missing cause info.	Deaths missing cause info.

Table 10. Causes of death among former View-Master workers, 1979-2001

Underlying cause of death	Number of deaths
All causes of death	964
All malignant neoplasms	308
Digestive organs and peritoneum	63
Esophagus	3
Stomach	6
Small Intestine	0
Colon, Rectum, Anus	28
Biliary passages and liver primary	3
Liver and intrahepatic bile duct	1
Gall bladder and other biliary	2
Pancreas	22
Respiratory system	94
Bronchus, trachea, lung	91
Breast	45
All uterine (women only)	12
Cervix (women only)	8
Other female genital organs (ovary)	5
Prostate (men only)	13
Kidney, renal pelvis, ureter	11
Bladder, other urinary organs	4
All lymphatic and hematopoietic	17
Hodgkins disease	2
Leukemia	5
Other lymphopoietic tissue	10
Diabetes mellitus	27
All heart disease	224
Ischemic heart disease	152
Cerebrovascular disease	50
Nonmalignant respiratory disease	72
Bronchitis, emphysema, asthma	6
Emphysema	4
Chronic liver disease and cirrhosis	21
Nephritis and nephrosis	4
All external causes of death	92
Accidents	49
Suicides	31
Other causes of death	136
Cause missing (not obtained in data search)	30

Table 11. Numbers of deaths and ratios of observed (Obs) to expected^a (Exp) deaths among View-Master workers in 1989-2001, by gender and underlying cause of death

Cause of death	Females			Males		
	Obs	Exp	PMR	Obs	Exp	PMR
All causes of death	430			186		
All malignant neoplasms	139	145.49	0.96	54	45.19	1.19
Digestive organs and peritoneum	25	26.36	0.95	18	10.51	1.71*
Esophagus	0	1.45	0	1	1.61	0.62
Stomach	0	1.91	0	3	1.08	2.79
Small Intestine	0	0.21	0	0	0.1	0
Colon, Rectum, Anus	12	12.04	1.00	6	4.16	1.44
Biliary passages and liver prim.	0	2.61	0	3	1.22	2.45
Liver and intrahepatic bile duct	0	1.66	0	1	0.99	1.01
Gall bladder and other biliary	0	0.95	0	2	0.24	8.41*
Pancreas	12	7.46	1.61	5	2.19	2.29
Respiratory system	41	42.07	0.97	13	15.38	0.85
Bronchus, trachea, lung	41	41.27	0.99	12	14.74	0.81
Breast	27	26.59	1.02	0	0.05	0
All uterine (women only)	7	6.04	1.16	0	0	.
Cervix (women only)	5	2.82	1.77	0	0	.
Other female genital organs (ovary)	4	9.47	0.42	0	0	.
Prostate (men only)	0	0	.	7	4.13	1.69
Kidney, renal pelvis, ureter	8	1.29	6.21**	2	0.72	2.76
Bladder, other urinary organs	2	2.57	0.78	2	1.64	1.22
All lymphatic and hematopoietic	8	12.49	0.64	3	5.14	0.58
Hodgkins disease	1	0.38	2.63	0	0.23	0
Leukemia	3	4.46	0.67	1	1.99	0.5
Other lymphopoietic tissue	4	7.65	0.52	2	2.92	0.69
Diabetes mellitus	14	14.60	0.96	2	4.34	0.46
All heart disease	107	87.91	1.22	38	44.92	0.85
Ischemic heart disease	68	57.79	1.18	24	34.12	0.70
Cerebrovascular disease	27	32.14	0.84	10	8.83	1.13
Nonmalignant respiratory disease	39	40.82	0.96	11	13.50	0.81
Bronchitis, emphysema, asthma	4	8.74	0.46	1	2.51	0.40
Emphysema	2	5.70	0.35	1	1.82	0.55
Chronic liver disease and cirrhosis	10	6.62	1.51	3	3.97	0.76
Nephritis and nephrosis	3	2.32	1.29	0	0.86	0
All external causes of death	27	26.98	1.00	27	32.22	0.84
Accidents	15	16.57	0.91	14	18.64	0.75
Suicides	9	6.72	1.34	10	9.88	1.01
Other causes of death	64	73.11	0.88	41	32.16	1.28
Cause missing (not obtained in search)	0	0	.	0	0	.

^a Based on the experience of all decedents in Oregon during 1989-2001, adjusted for age and gender.

^b Proportionate Mortality Ratio is computed as the number of observed deaths divided by the expected number.

* $P < 0.05$; ** $P < 0.01$

Table 12. Minimum (Min), maximum (Max), mean, and variance (Var) in the number of deaths per year, by gender and cause of death, among View-Master workers 1989-2001

Cause of death	Females					Males				
	Min	Max	Mean	Var	Var÷ Mean	Min	Max	Mean	Var	Var÷ Mean
All causes of death	18	44	33.08	69.08	2.09	6	23	14.31	27.73	1.94
All malignant neoplasms	3	19	10.69	12.90	1.21	1	8	4.15	4.97	1.20
Digestive organs and peritoneum	0	4	1.92	1.58	.82	0	4	1.38	1.76	1.27
Esophagus	0	0	.00	.00	.	0	1	.08	.08	1.00
Stomach	0	0	.00	.00	.	0	1	.23	.19	.83
Small Intestine	0	0	.00	.00	.	0	0	.00	.00	.
Colon, Rectum, Anus	0	3	.92	.91	.99	0	3	.46	.77	1.67
Biliary passages and liver primary	0	0	.00	.00	.	0	1	.23	.19	.83
Liver and intrahepatic bile duct	0	0	.00	.00	.	0	1	.08	.08	1.00
Gall bladder and other biliary	0	0	.00	.00	.	0	1	.15	.14	.92
Pancreas	0	2	.92	.74	.81	0	3	.38	.92	2.40
Respiratory system	1	6	3.15	2.47	.78	0	3	1.00	1.33	1.33
Bronchus, trachea, lung	1	6	3.15	2.47	.78	0	3	.92	1.08	1.17
Breast	0	6	2.08	2.91	1.40	0	0	.00	.00	.
All uterine (women only)	0	3	.54	.77	1.43	0	0	.00	.00	.
Cervix (women only)	0	3	.38	.76	1.97	0	0	.00	.00	.
Other female genital organs (ovary)	0	1	.31	.23	.75	0	0	.00	.00	.
Prostate (men only)	0	0	.00	.00	.	0	2	.54	.60	1.12
Kidney, renal pelvis, ureter	0	2	.62	.59	.96	0	2	.15	.31	2.00
Bladder, other urinary organs	0	1	.15	.14	.92	0	1	.15	.14	.92
All lymphatic and hematopoietic	0	2	.62	.59	.96	0	1	.23	.19	.83
Hodgkins disease	0	1	.08	.08	1.00	0	0	.00	.00	.
Leukemia	0	1	.23	.19	.83	0	1	.08	.08	1.00
Other lymphopoietic tissue	0	1	.31	.23	.75	0	1	.15	.14	.92
Diabetes mellitus	0	4	1.08	1.41	1.31	0	1	.15	.14	.92
All heart disease	5	13	8.23	8.19	1.00	0	7	2.92	3.91	1.34
Ischemic heart disease	2	9	5.23	5.36	1.02	0	6	1.85	2.64	1.43
Cerebrovascular disease	0	4	2.08	1.41	.68	0	3	.77	1.03	1.33
Nonmalignant respiratory disease	0	8	3.00	5.17	1.72	0	3	.85	.97	1.15
Bronchitis, emphysema, asthma	0	1	.31	.23	.75	0	1	.08	.08	1.00
Emphysema	0	1	.15	.14	.92	0	1	.08	.08	1.00
Chronic liver disease and cirrhosis	0	2	.77	.69	.90	0	1	.23	.19	.83
Nephritis and nephrosis	0	2	.23	.36	1.56	0	0	.00	.00	.
All external causes of death	1	6	2.08	1.74	.84	0	6	2.08	3.58	1.72
Accidents	0	3	1.15	.97	.84	0	4	1.08	1.58	1.46
Suicides	0	3	.69	.73	1.06	0	2	.77	.69	.90
Other causes of death	1	8	4.92	6.41	1.30	0	7	3.15	3.81	1.21
Cause missing (not obtained in data search)	0	0	.00	.00	.	0	0	.00	.00	.

Table 13. Number of deaths among View-Master workers in 1989-2001, for which gender information was unavailable, by underlying cause of death

		Gender Unknown	Females	Males
Cause of Death	N deaths	% of deaths	% of deaths	% of deaths
All causes of death	147	100.00	100.00	100.00
All malignant neoplasms	44	29.93	32.33	29.03
Digestive organs and peritoneum	4	2.72	5.81	9.68
Esophagus	0	.00	.00	0.54
Stomach	1	.68	.00	1.61
Small Intestine	0	.00	.00	.00
Colon, Rectum, Anus	1	.68	2.79	3.22
Biliary passages and liver primary	0	.00	.00	1.61
Liver and intrahepatic bile duct	0	.00	.00	.54
Gall bladder and other biliary	0	.00	.00	1.08
Pancreas	2	1.36	2.79	2.69
Respiratory system	20	13.61	9.53	6.99
Bronchus, trachea, lung	19	12.93	9.53	6.45
Breast	6	4.08	6.28	.00
All uterine (women only)	1	.68	1.63	.00
Cervix (women only)	1	.68	1.16	.00
Other female genital organs (ovary)	0	.00	.93	.00
Prostate (men only)	3	2.04	.00	3.76
Kidney, renal pelvis, ureter	0	.00	1.86	1.08
Bladder, other urinary organs	0	.00	.47	1.08
All lymphatic and hematopoietic	2	1.36	1.86	1.61
Hodgkins disease	0	.00	.23	.00
Leukemia	1	.68	.70	.54
Other lymphopoietic tissue	1	.68	.93	1.08
Diabetes mellitus	7	4.76	3.26	1.08
All heart disease	30	20.41	24.88	20.43
Ischemic heart disease	22	14.97	15.81	12.90
Cerebrovascular disease	2	1.36	6.28	5.38
Nonmalignant respiratory disease	12	8.16	9.07	5.91
Bronchitis, emphysema, asthma	1	.68	.93	.54
Emphysema	1	.68	.47	.54
Chronic liver disease and cirrhosis	2	1.36	2.33	1.61
Nephritis and nephrosis	1	.68	.70	.00
All external causes of death	16	10.88	6.28	14.52
Accidents	8	5.44	3.49	7.53
Suicides	6	4.08	2.09	5.38
Other causes of death	14	9.52	14.88	22.04
Cause missing (not obtained in data search)	19	12.93	.00	.00