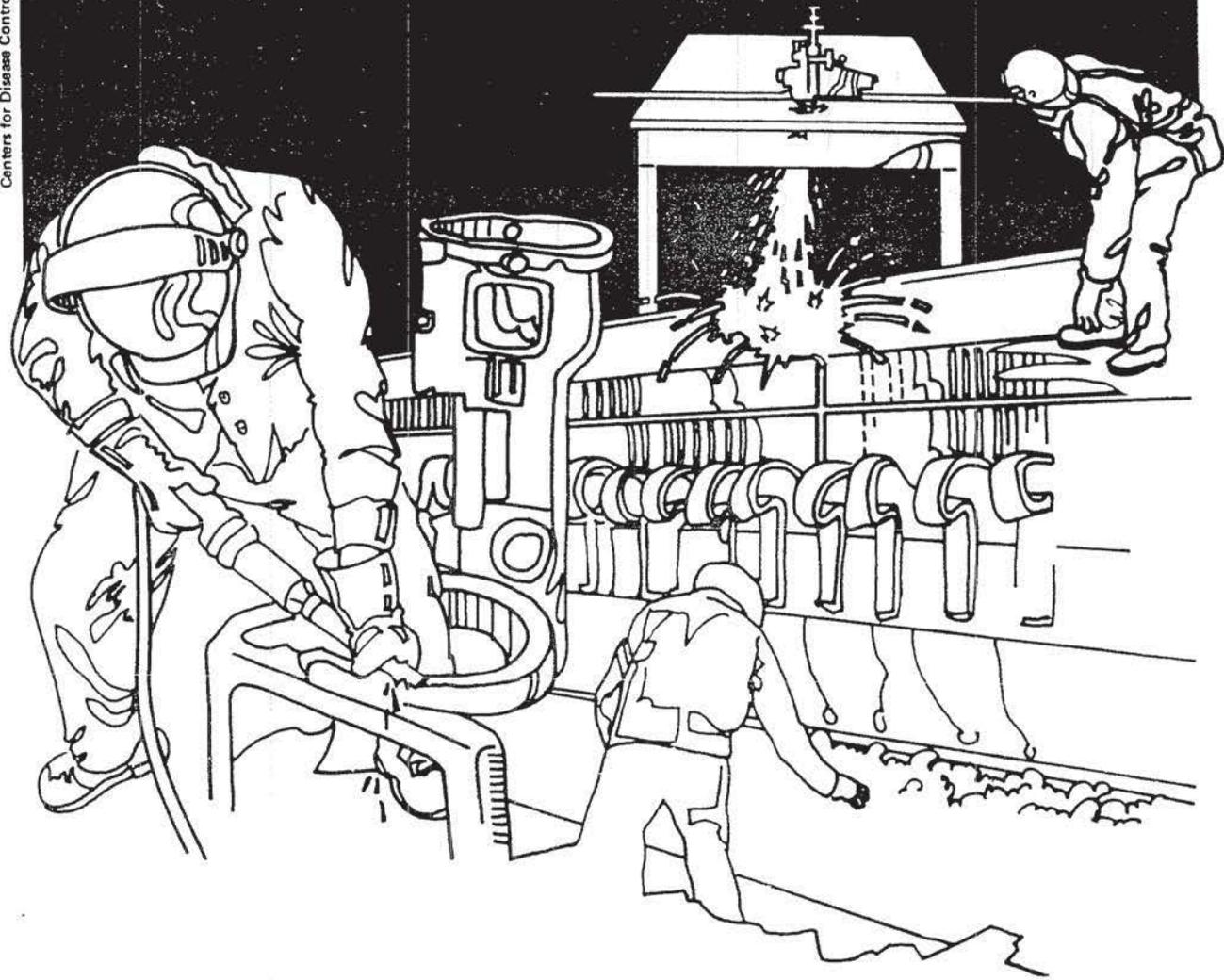


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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 81-030-1102
WASTEWATER TREATMENT PLANT
BROCKTON, MASSACHUSETTS

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 81-030-1102
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Wastewater Treatment Plant
Brockton, Massachusetts

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I. SUMMARY

In October 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Construction and General Laborers Union, Local 721, to evaluate an apparent excess incidence of gastrointestinal illness among construction workers at the Wastewater Treatment Plant, Brockton, Massachusetts. The Construction and General Laborers Union is an authorized representative of approximately 30 construction employees of Peabody NE, Inc. - the contractor responsible for the expansion of the wastewater treatment facility.

NIOSH visited the work site on December 9, 1980, and conducted private interviews with previously affected employees. Medical records were obtained on four affected employees evaluated at a nearby hospital.

Information obtained during the interviews indicated that the construction employees were experiencing a high incidence of gastrointestinal symptoms, especially stomach cramps and diarrhea. Symptoms occurred most when employees worked near the aeration tanks. The complaints reportedly increased during last summer's hot, humid weather. The medical records obtained from the local hospital indicated that pathogenic bacteria and parasites were not responsible for the diarrheal illnesses.

Because complaints were the highest during hot summer days, NIOSH returned in July 1981 to conduct environmental sampling for volatile organics using charcoal and silica gel tubes. Direct reading detector tubes were used to determine concentrations of hydrogen sulfide, sulfur dioxide, dimethyl sulfide, and ammonia. Analysis of the charcoal and silica gel tubes revealed the presence of only negligible amounts of various organic substances. All direct reading detector tube measurements were negative.

Since the NIOSH site visits, hand-washing and temporary eating facilities have been made available at the site. Construction in the immediate vicinity of the existing aeration tanks has been completed. The incidence of gastrointestinal illnesses has decreased.

Based on environmental sampling, NIOSH concludes that a chemical agent was not responsible for the employees' complaints. Based on a review of the existing literature on wastewater aerosols and disease, NIOSH believes that the symptoms were likely due to exposure to a variety of microorganisms and, possibly, bacterial endotoxin. Avoiding respiratory exposure to the wastewater aerosol and maintaining improved sanitation procedures should prevent the development of excess gastrointestinal illness.

Keywords: SIC #1623 (Heavy Construction - Water, Sewer...Construction); waste water, sewage water, aerosol, microorganism, bacteria, virus, stomach cramps, diarrhea, gastrointestinal symptoms.

II. INTRODUCTION

In October 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Construction and General Laborers Union, Local 721, to evaluate an apparent excess incidence of gastrointestinal illness among construction workers at the Wastewater Treatment Plant, Brockton, Massachusetts. The request stated that employees involved in new construction at the existing plant were complaining of chronic dysentery, stomach cramps, fever, sore throat, and headache. The Construction and General Laborers Union is an authorized representative of approximately 30 construction employees of Peabody NE, Inc. - the contractor responsible for the expansion of the wastewater treatment facility. Other employees of Peabody NE, Inc., at the site include carpenters, iron workers, operating engineers, inspectors, and cement finishers.

NIOSH visited the work site on December 9, 1980, to determine the scope of the problem. Private employee interviews were conducted and the facility engineers were interviewed to gather information about the wastewater treatment process.

Because complaints were greatest during hot summer days, NIOSH returned to the site on July 15, 1981, to conduct sampling for airborne chemical substances.

III. BACKGROUND

A. Process

The facility handles all the waste water from the city of Brockton and some from surrounding towns. The system is designed to treat domestic and non-hazardous industrial waste. The system handles discharge from four canneries and three plating companies, as well as other light industrial plants. The industrial waste chemist of the city regularly monitors for trivalent chrome, which potentially could be discharged by a plating company. No hazardous chemicals or other heavy metals are produced by other industries discharging into the system. Thus routine monitoring of additional substances is not done.

The wastewater treatment facility employs three stages of treatment:

Primary treatment: Incoming waste water is pumped into a large 3 million gallon sedimentation tank. Coarse suspended solids settle to the bottom and are treated with ferric chloride and lime before disposal.

Secondary treatment: Waste water is then pumped into aeration tanks which utilize activated sludge (Bio-mass) to remove a higher proportion of putrescible, biologically degradable organic matter. The excess sludge is separated in sedimentation basins and disposed of by digestion.

Tertiary treatment: The secondary effluent is monitored for coliform bacteria and is chlorinated as needed before discharge into the river.

B. New Construction

The facility has reached its handling capacity and is currently being expanded. Construction of new buildings, aeration tanks, and sedimentation basins began in the spring of 1980. The project will be completed in May 1983. The new tanks are located immediately adjacent to the existing, functioning ones. The construction of the tanks involves excavating the ground, constructing iron framework and wood frames, and pouring cement.

The site contractor is Peabody NE, Inc., of North Easton, Massachusetts. The contractor employs laborers, carpenters, and iron workers, as well as operation engineers and inspectors. The construction is seasonal, with relatively little activity occurring during the late fall and winter. During the summer, up to 80 employees work at the site, including approximately 35 members of the Construction and General Laborers Union.

The employees wear their own work clothes. Some employees wear gloves, while most do not. Initially, no running water was available for construction employees to wash their hands. Cold water was made available in the spring of 1981. Portable chemical toilet facilities are provided. Employees initially ate by their cars which are parked in an unpaved area at the site. Early in 1981, sheds in which employees could eat lunch were built on site.

Shortly after beginning work, employees reported noticing a feculent odor and feeling nauseated when working around the existing tanks and basins. The odor is worse immediately downwind from the aeration tanks, where a fine mist can be perceived arising from the tank. The odor increases on hot, humid days.

Through the summer of 1980, many employees developed gastrointestinal symptoms with stomach cramps and diarrhea. The Union noted that there was increased absenteeism among members working at the site. In September 1980, four affected employees were sent for evaluation to an occupational health clinic at a local hospital. No etiology for the diarrhea was identified.

C. Literature Review

Construction workers at wastewater treatment plants have direct contact with the dirt of the construction site and respiratory exposure to the mist or aerosol generated from the functioning aeration and sedimentation tanks. Health effects among these construction workers have not been specifically evaluated; however, the health effects of exposure to wastewater aerosols have been extensively studied.

Aerosols are tiny droplet nuclei generated from the sewage water during treatment. They may contain chemicals, as well as many microorganisms, including coliform bacteria, pathogenic bacteria, and viruses(1). Chemicals in waste water can include numerous heavy metals, chlorinated hydrocarbons, solvents, and other volatile organic compounds(2,3). Non-volatile contaminants can be emitted into the atmosphere via aerosolization from the treatment facility. Additionally, sewage workers can be exposed to hydrogen sulfide, methane, carbon dioxide, and ammonia produced from the biological degradation of typical domestic waste(3).

In general, chemical contaminants in waste water do not represent a significant health risk because the natural dissipation of the chemicals in the air is sufficient to keep airborne concentrations low. Health effects have been observed when excessive amounts of specific industrial chemicals have been discharged into sewerage systems(2).

On the other hand, the wastewater aerosols have been shown consistently to carry viable microorganisms substantial distances from their source in the tanks and basins. The Environmental Protection Agency (EPA) has sponsored several investigations of potential health effects among persons residing by or working at wastewater treatment facilities. Overall, the results indicate that there are probably no significant health risks associated with exposure to wastewater aerosols(1)*. Nevertheless, an increased incidence of gastrointestinal disorders has been observed by several investigators.

Population studies have generally not found adverse health effects among residents living near wastewater treatment plants. Some studies have demonstrated a weak association between living distance from plants and rates of minor infectious diseases. Northrop et al. demonstrated that a wastewater treatment plant was a source of microorganisms, but found no obvious adverse health effects among nearby residents(4). Johnson et al. conducted a household health survey near a newly activated sludge facility(5). The residents reported a higher incidence of skin disease and gastrointestinal symptoms after the plant became operational. Tests of subjects' blood for antibodies to viruses and attempted isolation of microorganisms yielded no clinical evidence of specific infections.

Fannin et al. found that persons dwelling nearest a wastewater treatment plant experienced higher than expected rates of respiratory and gastrointestinal illnesses, when stratified by income and education(6). However, the excess illness occurred primarily among those individuals in the lowest income and education classifications. The investigators suggested that the excess gastrointestinal illness rates may be attributable to higher living density (and reduced levels of sanitation) in lower socio-economic families rather than to the wastewater treatment plant. This assertion was not clearly substantiated. While it is known that rates of gastrointestinal illness tend to be higher among large families, the investigators did not demonstrate that the lower socio-economic-status families in the study population had more family members than other participating families.

Occupational studies of workers exposed to sewage water have found excess rates of gastrointestinal illness, but have not been able to demonstrate a specific cause for this "Sewage Workers' Syndrome"(7). Rylander et al. evaluated workers at six sewage treatment plants in Sweden, using workers at drinking water plants as controls(8). Environmental sampling indicated a high number of airborne gram-negative bacteria at the sewage treatment plants. The highest number - up to 10^5 colony forming units per cubic meter of air (cfu/M³) - were found near the aeration basins. During

* The results of several EPA-sponsored and other studies were presented in a recent symposium (reference 1). Many of the following references are to reports presented at the symposium. Original contract reports and published papers on the same studies are referenced in the symposium reports.

interviews, 32% of the workers in the sewage treatment plants reported diarrhea or acute gastrointestinal symptoms, compared to 2% in the drinking water plants. No significant difference between the two groups was found in white blood count or distribution of the types of white blood cells; in the IgG, IgM, and IgA levels; or in the serum levels of specific antibodies to endotoxin* from gram-negative bacteria found in the sewage water. No specific cause for the gastrointestinal symptoms was demonstrated; however, the investigators suggested that the toxic effect of the high load of bacterial endotoxin was possibly responsible for the symptoms.

Clark et al. conducted a prospective seroepidemiologic study of waste water-exposed workers and controls(10). There was no consistent evidence of increased parasitic, bacterial, or viral infections, as indicated by stool examinations, cultures, and antibody surveys. They did observe an increased level of gastrointestinal illness in inexperienced sewage-exposed workers, compared to experienced workers and controls. The cause of these illnesses was not identified.

Clark indicated in a recent communication that further investigation has demonstrated elevated antibody levels among some, but not all, of the inexperienced workers to Roto viruses and Norwalk Agent - viral organisms not evaluated previously(11). He stated that these agents alone were not responsible for all the observed excess of illness. It is likely that the increased incidence of gastrointestinal symptoms observed in the various studies is due to infection by a variety of microorganisms - including bacteria, enteroviruses, and other viruses, such as Roto viruses and Norwalk Agent - and possibly due to the toxic effects of bacterial endotoxin.

IV. MATERIALS AND METHODS

A. Environmental

Air samples were collected on a charcoal tube and a silica gel tube on July 15, 1981. The samples were collected directly over an aeration tank, where the mist concentration was highest. These tubes, along with blanks of each, were analyzed for volatile organics by gas chromatography/mass spectrophotometry.

Direct reading detector tubes were used to determine concentrations of hydrogen sulfide, sulfur dioxide, dimethyl sulfide, and ammonia.

Conversations with the industrial waste chemist of the city revealed that trivalent chrome is routinely monitored prior to entry into the system. No significant amounts have been detected during the past five years. No other chemical analyses are routinely performed.

* Endotoxin is the lipopolysaccharide moiety of the cell walls of gram-negative bacteria(9). It acts as a systemic toxin by affecting blood vessels supplying oxygen to the organs of the body. Small doses can cause fever, headache, malaise, and possibly gastrointestinal symptoms. Because the symptoms are due to a toxic effect rather than infection, they resolve relatively rapidly after exposure ends.

B. Medical

NIOSH privately interviewed ten previously affected employees on the day of the site visit. They were asked about work locations, odors, health symptoms, and symptoms among family members. Employee attendance records were reviewed. NIOSH also interviewed regular employees of the Wastewater Treatment Plant.

NIOSH reviewed the medical records of the four affected employees evaluated at the local hospital.

Considering the results obtained in the several prospective population and occupational studies discussed above, it was decided that a further medical evaluation is not justified or feasible. A major method of infectious disease ascertainment is through the use of serology(12). This technique involves the collection of a blood sample and determination of the amount of antibodies to specific microorganisms. A second sample must be collected at a later time and the antibody levels measured again. A significant increase in the specific antibody levels is considered indicative of infection with the specific microorganism.

Unfortunately, the method is limited because it is necessary to test specifically for the correct agent. It is not a broad screen for infections, but is utilized to identify particular viruses and bacteria. It is not feasible to test all of the possible organisms present in waste water. Secondly, pre- and post-infection serum specimens are needed for comparison. NIOSH received the request for assistance in October 1980, after the employees had worked at the site for several months. Most had experienced at least one episode of illness. Thus, pre-infection serum samples could not be obtained. It is extremely unlikely that NIOSH could identify a specific biological agent, even by conducting an extensive medical study.

V. EVALUATION CRITERIA

No governmental criteria applicable to workers exist for levels of airborne microorganisms in wastewater treatment facilities.

During environmental sampling for chemical contaminants only toluene and xylene were specifically identified. The NIOSH recommended standard for toluene is 375 milligrams per cubic meter of air (mg/M^3), based on a 10-hour workday, 40-hour work week. The NIOSH recommended standard for xylene is 434 mg/M^3 .

VI. RESULTS AND DISCUSSION

A. Environmental

Toluene was found on the charcoal blank and on the charcoal sample. Compounds found on the sample, but not on the blank were: xylene, C₉-C₁₂ aliphatic hydrocarbons, and higher aromatic compounds (molecular weight of 120-134) - all in amounts too small to quantitate accurately.

Only toluene was found on the silica gel blank and sample.

The quantity of toluene present was 0.08 mg/M³ - two ten-thousandth of the NIOSH recommended standard. The quantity of xylene was less than 0.05 mg/M³, compared to the NIOSH recommended standard of 434 mg/M³.

Direct reading measurements for hydrogen sulfide, sulfur dioxide, dimethyl sulfide, and ammonia were unremarkable.

B. Medical

The regular employees of the wastewater treatment plant reported no excess incidence of gastrointestinal complaints. They noted that regular employees spend most of their time inside control buildings. They work around the aeration tank and sedimentation basin only when collecting samples of waste water for analysis. They wear protective coveralls and receive instruction in sanitary procedures to avoid getting infections from the waste water.

The construction employees interviewed by NIOSH described having a spectrum of gastrointestinal disorders which they associated with working at the construction site. Three general patterns were described: 1) stomach cramps and diarrhea occurring during the workday, with slight relief by late evening and improvement over weekends and vacations. These persons noted that the symptoms gradually improved after a few months at the work site; 2) three to five discrete episodes of nausea and diarrhea over the several months, each episode lasting one to three days; and 3) episodes of nausea, diarrhea, and some vomiting lasting several days, followed by up to a week of feeling weak. Only two persons reported experiencing the last pattern. Some individuals reported experiencing a mixture of patterns.

Employees agreed that the frequency of complaints was greatest during the first summer working at the site. Symptoms occurred most when employees worked near the aeration tanks, especially when working downwind from the tanks in the mist arising from the tanks. They also occurred more when employees worked in the sludge-fill area, where processed sludge has accumulated for years. Complaints increased substantially during hot, humid weather. Several persons noted that the feculent odor near the aeration tanks made them nauseated, even when they did not develop subsequent stomach cramps or diarrhea.

Severe headache, cough, dyspnea, respiratory irritation, and chest pain were not reported. None of the affected employees noted blood or pus in his stools. No other health complaints were reported. Family members of employees apparently were not affected.

Subsequent conversations with the construction workers revealed that the incidence of gastrointestinal complaints remained higher than normal during the summer of 1981, but was substantially lower than during 1980. Two sinks were installed early in 1981 for hand-washing, but because the construction

site is large, many workers do not routinely go to the sinks and wash their hands before smoking or eating. Construction around the existing aeration tanks was completed by the end of 1981. Workers will not spend much time in those areas in the future.

The records of the four employees seen at the local hospital in 1980 indicated that physical examinations, complete blood counts, routine serum chemistry profiles, chest X-rays, and stool cultures were all normal. Stool samples were negative for ova and parasites. No specific etiology was identified. Assuming that the four employees were representative, these results indicate that pathogenic bacteria and parasites were not responsible for the employees complaints.

It seems clear that the construction employees were highly exposed to a wide variety of microorganisms in the wastewater aerosol and by direct contact with the dirt at the construction site. Studies have previously demonstrated that these aerosols contain large numbers of viable microorganisms. Some studies have also noted an increased incidence of gastrointestinal illness among exposed workers. It should be noted that wastewater treatment plant workers primarily work inside control buildings and tend to minimize the time they spend near the aeration tanks and sedimentation basins. They also do not work directly in the dirt surrounding the basins.

No specific biological agent was identified as causing the complaints, and it is likely that a combination of microorganisms and, possibly, bacterial endotoxin was responsible for the spectrum of gastrointestinal symptoms reported by the construction employees. Regardless of the specific biological agent(s) responsible, employees' complaints would likely be reduced by avoiding working downwind from the aeration tanks and sedimentation basins and by maintaining improved sanitation procedures.

VII. CONCLUSIONS

Construction employees working in the vicinity of the existing aeration tanks experienced an increased incidence of gastrointestinal symptoms, especially nausea, stomach cramps, and diarrhea. No other significant health effects were identified. The incidence of complaints has decreased since hand-washing and eating facilities were provided. Employees now spend less time in the vicinity of the existing aeration tanks.

Based on environmental sampling, NIOSH concludes that a chemical agent was not responsible for the employees' complaints. A medical evaluation of four employees indicated that pathogenic bacteria and parasites were not responsible for the reported illnesses. Based on a review of the existing literature on wastewater aerosols and disease, NIOSH believes that the symptoms were likely due to exposure to a variety of microorganisms and, possibly, bacterial endotoxin.

VIII. RECOMMENDATIONS

1. To the extent feasible, employees should avoid working downwind from the aeration tanks and sedimentation basins. It is understood by NIOSH that construction involving these areas has been completed.
2. Employees should wash their hands before smoking or eating. The employer should provide washing facilities in several convenient locations to encourage frequent hand-washing.
3. Sanitation procedures established for the Brockton Wastewater Treatment Plant workers, including employee education, should be applied to the construction workers to the extent practicable.

IX. AUTHORSHIP AND ACKNOWLEDGEMENT

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Hazard Evaluations and Technical Assistance Branch
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X. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

For the purpose of informing the "affected employees", the employer should post this report for at least 30 days in a prominent place(s) near where the employees work.

Copies of this report will be available from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio, 45226, for 90 days. Thereafter, copies will be available from the National Technical Information Service (NTIS), Springfield, Virginia. Information concerning its availability through NTIS can be obtained from the NIOSH publication office at the above Cincinnati address.

Copies of this report have been sent to:

Construction and General Laborers Union, Local 721
Peabody NE, Inc.
Massachusetts State Department of Health
Occupational Safety and Health Administration, Region I