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<b>16. Abstract (Limit: 200 words)</b> On March 29, 1977 the Morris Forman Wastewater Treatment Plant in Louisville, Kentucky was evacuated and closed after it was discovered that wastewater entering the plant was contaminated with hexachlorocyclopentadiene and octachlorocyclopentene. Treatment plant workers reported acute symptoms including headache; irritation of eyes, nose, throat, and skin; cough; chest discomfort; and shortness of breath. On April 2, the Mayor of the City of Louisville requested the National Institute for Occupational Safety and Health (NIOSH) to assist the Metropolitan Sewer District in ensuring that safe and healthful working conditions existed for the workers involved in decontamination of the treatment plant and its contributory sewers. NIOSH provided continuous environmental and medical surveillance throughout the decontamination efforts. The treatment plant resumed near-normal operations in June 1977. This report represents the findings of this NIOSH technical assistance effort.  NIOSH found that workers acutely exposed to HCCPD (hexachlorocyclopentadiene) complained of such symptoms as headache, eye irritation, sore throat, cough, chest discomfort, skin irritation, nausea, and fatigue. These symptoms persisted at least 6 weeks in 15-46% of the cases. On serial testing, 19% of a crew of exposed workers wearing protective gear had at least one abnormal liver function test at some time during the surveillance period; the HCCPD levels to which they were exposed are			
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HAZARD EVALUATION AND TECHNICAL ASSISTANCE  
REPORT NO. TA 77-39

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
METROPOLITAN SEWER DISTRICT  
LOUISVILLE, KENTUCKY

AUGUST 1978

Assistance Requested By:  
Mayor  
City of Louisville  
Louisville, Kentucky

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I. SUMMARY

On March 29, 1977 the Morris Forman Wastewater Treatment Plant in Louisville, Kentucky was evacuated and closed after it was discovered that wastewater entering the plant was contaminated with hexachlorocyclopentadiene and octachlorocyclopentene. Treatment plant workers reported acute symptoms including headache; irritation of eyes, nose, throat, and skin; cough; chest discomfort; and shortness of breath. On April 2, the Mayor of the City of Louisville requested the National Institute for Occupational Safety and Health (NIOSH) to assist the Metropolitan Sewer District in ensuring that safe and healthful working conditions existed for the workers involved in decontamination of the treatment plant and its contributory sewers. NIOSH provided continuous environmental and medical surveillance throughout the decontamination efforts. The treatment plant resumed near-normal operations in June, 1977. This report presents the findings of this NIOSH technical assistance effort.

NIOSH's activities included (1) monitoring of worker exposures to the contaminants, hexachlorocyclopentadiene (HCCPD) and octachlorocyclopentene (OCCP), and to other health and safety hazards, (2) advising on the use and selection of personal protective equipment, ventilation requirements, and work practices, (3) training of sewer district laboratory technicians in the appropriate air sampling and analytical procedures, (4) medical monitoring of clean-up workers, and (5) developing a method for measuring HCCPD and OCCP in urine and attempting to develop a method for measuring them in blood. In addition, during the year following this initial involvement, NIOSH provided advice concerning environmental and medical surveillance, work practices, and personal protective equipment to be used during the clean-up of the remaining contaminated sewers.

The myriad of different conditions of exposure by the workers precludes any simple statistical summary of the HCCPD and OCCP concentrations that existed during the decontamination effort. Other than stating that the HCCPD and OCCP concentrations ranged from <0.3 to 11801 ppb and <0.1 to 1488 ppb, respectively. By comparison, the American Conference of Governmental Industrial Hygienists (1977) recommends an 8-hour time-weighted average exposure of 10 ppb HCCPD with a tentative short term 15-minute exposure limit of 30 ppb. No environmental criteria has been established for OCCP.

NIOSH found that workers acutely exposed to HCCPD complained of such symptoms as headache, eye irritation, sore throat, cough, chest discomfort, skin irritation, nausea, and fatigue. These symptoms persisted at least 6 weeks in 15-46% of the cases. On serial testing, 19% of a crew of exposed workers wearing protective gear had at least one abnormal liver function test at some time during the surveillance period; the HCCPD levels to which they were exposed are uncertain. There is no data to indicate whether irreversible biologic effects occurred as a result of these exposures.

## II. INTRODUCTION AND BACKGROUND

Major chemical contamination of the Morris Forman Wastewater Treatment Plant in Louisville, Kentucky occurred about March 26, 1977. On March 26, an odiferous, highly viscous, sticky substance entered the treatment plant and coated the bar-screens and grit collection systems in the primary treatment area. Attempts to remove the material with steam produced a dense vapor cloud (a "blue haze" according to the workers), which permeated the grit removal and sludge handling areas and caused approximately 20 workers to seek medical treatment for tracheobronchial irritation. Analysis by the U.S. Environmental Protection Agency showed the wastewater to be chemically contaminated with hexachlorocyclopentadiene (HCCPD) and octachlorocyclopentene (OCCP). Subsequent analysis of a sludge sample showed the presence of other chlorinated cyclohydrocarbons, but of much lesser concentrations (Table 1).

Hexachlorocyclopentadiene is a dense, oily, slightly water soluble liquid used as an intermediate in the production of pesticidal and industrial chemicals.<sup>1</sup> Some important products derived from HCCPD (via Diel-Alder reactions) are the chlorinated cyclodiene insecticides aldrin, dieldrin, endrin, chlordane, heptachlor, endosulfan, Kepone®, and mirex; the fire-retardant monomers chlorendic acid and chlorendic anhydride used in polyester resins; and the fire retardants plastic additives known as Dechloranes. Octachlorocyclopentene is also a chemical intermediate, but of limited use.<sup>2</sup> It is primarily used as a chlorinating agent in the preparation of HCCPD with limited use in producing fluorine compounds upon being fluorinated.

An estimated 6 tons equivalent of HCCPD and OCCP, dispersed in No. 4 fuel oil, was dumped directly into the municipal sewer system's Western Outfall (Broadway Street) Sewer which carried the contamination into the treatment plant. Although the exact date of the dumping is not known (or at least has not been released pending litigation), the epidemiologic evidence<sup>3</sup> (Figure 1) suggests that it may have occurred as early as March 14 when there were concurrent above-background-level increases in detection of odor and in symptoms. The symptoms included headache; irritation of eyes, nose, throat, and skin; cough; chest discomfort; and shortness of breath. Due to the compounds apparent potential for severe toxicity, the treatment plant was voluntarily closed by the Metropolitan Sewer District (MSD) on March 29. Thereafter, until the partial reopening on June 5, 1977, 105,000,000 gallons per day of domestic and industrial wastes were diverted directly to the Ohio River, and approximately 6,000,000 gallons of contaminated sludges and wastewaters from the treatment processing operations were accumulated in 3 anaerobic digesters. This sludge is currently being disposed of at the treatment plant through low pressure wet air oxidation (Zimpro®), and vacuum filtration and incineration processing. Additionally, during this same period, the equivalent of approximately 300,000 gallons of heavy sludge and grit from the sewers and grit collection operation have been packaged in disposable steel containers and shipped to a burial site in Wilsonville, Illinois for ultimate disposal.

The National Institute for Occupational Safety and Health (NIOSH) first became involved on March 30, 1977, when the Director of Surveillance and Analysis, U.S. Environmental Protection Agency, Region IV contacted the Director, Division of Surveillance, Hazard Evaluations, and Field Studies, NIOSH, requesting assistance. On March 31, a NIOSH investigation team proceeded to MSD in Louisville to obtain a general orientation to the problem, conduct exploratory environmental sampling, and retrieve biological specimens previously collected by the Jefferson County Health Department for analysis by NIOSH. On April 2, NIOSH received an official request from the Mayor of the City of Louisville to provide technical assistance to MSD during the removal of the toxic chemicals from the Morris Forman Wastewater Treatment Plant and its contributory sewer lines. Subsequently, NIOSH assisted MSD in ensuring that safe and healthful working conditions existed for MSD employees involved throughout the hazardous clean-up operations. NIOSH terminated its on site assistance (which began April 2) on June 5 because (a) approximately 85% of normal flow was passing through the treatment plant, (b) the workers were out of the sewers, (c) treatment plant technicians had been trained by NIOSH in sampling and analytical methodologies necessary for them to assume future environmental monitoring needs, and (d) a preliminary environmental-medical surveillance program was prepared by NIOSH for presentation to MSD management on June 14, 1977. However, a commitment was offered to MSD that NIOSH industrial hygiene and medical personnel would be available for consultation.

NIOSH technical assistance included the following activities directed toward minimizing or preventing respiratory, dermal, and oral exposure to HCCPD, OCCP, and other potentially toxic organic and inorganic compounds during the clean-up: (1) monitoring of worker exposures to the contaminants, HCCPD and OCCP, and to other health and safety hazards, (2) advising on the use and selection of personal protective equipment, ventilation requirements, and work practices, (3) training of sewer district laboratory technicians in the appropriate air sampling and analytical procedures, (4) medical monitoring of clean-up workers, and (5) developing a method for measuring HCCPD and OCCP in urine and attempting to develop a method for measuring them in blood. In addition, during the year following this initial involvement, NIOSH provided advice concerning environmental and medical surveillance, work practices, and personal protective equipment to be used during the clean-up of the remaining contaminated sewers.

The other agencies who so ably participated, and a chronological listing and description of events that transpired from March 26 through July 25, are summarized in Appendix I.

The effort to clean the contaminated parts of the sewer system is substantially complete. As of January 1, 1978, the plant was treating approximately 85 million gallons of flow per day. To date, two major work efforts remain to be accomplished before MSD's operations can be completely back to normal. There are decontamination or removal and disposal of contaminated sludge from (a) approximately 9,700 linear feet of the 9' - 6" and 10' - 6" Western Outfall Sewer and (b) approximately 1,790 linear feet of 42" and 4,900 linear feet of 60" sewers, called the Western Interceptor. There is an estimated 250 to 300 cubic yards of sludge which has been contaminated with HCCPD and OCCP in these sewers.

### III. MORRIS FORMAN WASTEWATER TREATMENT PLANT - GENERAL DESCRIPTION OF THE OPERATION

The Morris Forman Wastewater Treatment Plant located in southwest Louisville is operated by the Metropolitan Sewer District (MSD) and services Louisville and parts of Jefferson County, Kentucky. The plant has both primary and secondary treatment facilities with a present average flowrate of 105,000,000 gallons per day (MGD). Primary treatment removes a substantial amount of suspended matter and scum using mechanical methods, and secondary treatment uses biological methods in which aerobic microorganisms reduce the soluble and insoluble contaminants present in the wastewater. A flow diagram of the wastewater is provided in Figure 2. A brief description of the basic treatment methods follows:

The wastewater enters the plant through 2 major interceptor sewers; the 11' semi-elliptical Ohio River Interceptor and the 72" diameter Southwestern Outfall Sewer. The raw wastewater is received by the influent screen chamber and is distributed to any or all of 4 mechanically cleaned bar screens with each screen followed by an aerated grit channel. The screenings and grit removed from the flow are moved on belt conveyors to either a rotary drum incinerator or to a truck positioned in the Grit Loading Building for hauling to a commercial landfill. The bar screens and grit removal chambers are housed in or beneath the Screen and Grit Building.

The partially treated wastewater flows from the grit tanks through an aerated channel to the aerated influent channel before entering 1 of 4 primary settling tanks. The function of the primary settling tanks is to retain the wastewater for a sufficient length of time (usually 2 hours) to permit the suspended solids of settleable character to settle to the bottom. The settled solids are moved along the bottom to sludge hoppers at the influent end of each tank by mechanical rakes supported from a carriage moving on rails above the sewage level. The raw sludge is periodically pumped from the hoppers to the rotary kiln incinerator or to anaerobic digesters where it decomposes before being pumped through the sludge well and to the final filtering, drying, and incineration processes. The raw sludge is periodically pumped from the hoppers to anaerobic digesters where it decomposes before being pumped to a sludge well, thence, to a blending well, through a wet oxidation process, gravity thickeners, vacuum filters, and to an incineration process. The resultant ashes are hauled by truck to a sanitary landfill.

Settled wastewater from the primary settling tanks flows to the secondary treatment system where it undergoes the activated sludge process using high purity oxygen. The secondary system consists of oxygenation tanks, final settling tanks, and return sludge pumps. Basically, the partially treated wastewater from the primary settling tanks and oxygen are mixed together mechanically. The mixture of oxygen and microorganisms reduces the organic and other contaminants in the wastewater and forms a floc. The effluent from the oxygenation tank enters the final settling tanks where the floc formed in the oxygenation tank is settled. The sludge which collects in the settling tank is returned to the oxygenation tank to maintain the biological growth and the effluent from the settling tanks, relatively free of organic contaminants, passes to the chlorine contact basin for disinfection. The treated wastewater is then discharged into the Ohio River.

#### IV. STUDY DESIGN AND METHODS

##### 1. Environmental

April 2 through June 5, 1977 NIOSH provided continued on-site assistance to MSD to insure that safe and healthful working conditions existed during decontamination of the treatment plant and its contributory sewer lines. The available toxicological data and threshold limit value (10 ppb) for HCCPD were used as guidelines by NIOSH in recommending specific work practices and procedures and types of personal protective equipment to be employed by the workers. To date, the toxicology of OCCP has not been documented in the literature.

The workers' airborne exposures to HCCPD and OCCP were concurrently monitored during the various decontamination operations using both personal and work area sampling techniques. The air sampling train consisted of a glass tube containing pre-extracted chromosorb 102 in series with a battery-powered vacuum pump operating at 50 or 200 cubic centimeters per minute (cc/min). The different flow rates were required to adequately assess the various conditions of exposure. For example, when the contaminant concentrations were expected to be low and the exposure period short, the higher flow rate was required to achieve an adequate sample for analysis. The analytes were desorbed from pre-extracted chromosorb 102 with carbon disulfide and analyzed using a gas chromatograph equipped with a flame ionization detector. (The analytical procedure is fully described in Appendix II.)

##### 2. Medical

Dr. Dale Morse of CDC provided the initial medical assistance during March 31 through April 3, 1977. His involvement consisted of (a) conducting a community survey to rule out a generalized health problem, and (b) an evaluation of chemically exposed sewage plant employees to determine whether or not any morbidity had occurred in these workers.<sup>4</sup> The questionnaire survey sampled 212 individuals in a 50-block area of potentially highest exposure and revealed no evidence of unusual symptomatology. The survey of 145 plant employees showed that 86 (59%) had complained of transient eye irritation. Symptoms occurred in workers throughout the plant, with the highest attack rates occurring in employees who worked in the primary treatment areas. Biological samples obtained of 41 employees 3 days after the plant closed showed evidence of proteinuria and elevation of serum lactic dehydrogenase, but these findings were not corroborated by further testing 3 weeks later.

After April 3, NIOSH assumed the responsibility for medical follow-up during the clean-up operations. The NIOSH effort consisted of the following:

a. A non-directed follow-up questionnaire was distributed through the plant superintendant's office to all employees in the plant in order to determine how persistent the symptomatology had been after the initial chemical exposure in March.

Distribution and recovery of completed questionnaires occurred over the last two weeks in May. Of about 200 persons working on the plant site in late March, 1977, 182 returned a questionnaire (91%). This return rate would have been higher if some questionnaires had not been lost in the mail. Persons actively involved in clean-up were excluded, since persistence of their symptoms could be related to continued exposure.

b. Medical records were reviewed on May 10, 1977, of the 90 employees who had seen the plant physician from late-March, 1977, until May 10, 1977.

c. On April 20, 1977, NIOSH personnel collected repeat biologic samples on 20 of 23 employees who had shown some abnormality on the testing done by the CDC physicians on March 31 - April 2, 1977. The three persons who failed to appear for testing were directed to the plant physician for follow-up.

d. Biological specimens were collected from 7 NIOSH industrial hygienists and 2 EPA environmental technicians who were exposed to chemicals in the plant and sewer system. All 9 received a complete blood count and a serum chemistry; only the two EPA technicians received a urinalysis. Pre- and post-exposure testing was done on 4 of the nine persons.

e. NIOSH personnel conducted medical monitoring of employees who were actively involved in plant clean-up on April 8, 12, and 20, and May 5 and 19, 1977. Monitoring consisted of a questionnaire; a brief physical examination directed mainly to signs of irritation of mucous membranes, skin, or lungs; blood specimens for complete blood count and serum chemistry (serum glutamic-oxalacetic transaminase, lactic dehydrogenase, alkaline phosphatase, total bilirubin, albumin, total protein, cholesterol, uric acid, blood urea nitrogen, creatinine, glucose, inorganic phosphate, calcium); and urine for routine urinalysis (specific gravity, pH, albumin, glucose, acetone, bile, blood, urobilinogen, microscopic). These routine blood and urine tests were all done by the same NIOSH contract lab. Blood and urine specimens were collected from several persons with a history of probable exposure; direct analysis of these specimens for hexachlorocyclopentadiene and its metabolites was attempted by NIOSH labs in the Division of Biomedical and Behavioral Sciences.

On April 8 and 12, 1977, baseline monitoring was done on employees who had been selected to start the clean-up process.

At NIOSH's request, only employees who had not reported serious symptoms during the end of March were selected to be in the clean-up crew.

On April 20, May 5, and May 19, follow-up monitoring was done on persons who had been involved in clean-up of contaminated areas of the plant. Some of the employees monitored on May 19 had not received any pre-clean-up testing due to some problems in coordination of this massive and complex clean-up effort.

V. ENVIRONMENTAL CRITERIA AND TOXICOLOGICAL PROPERTIES

a. Environmental Criteria

NIOSH has not proposed a recommended criteria nor has the U.S. Department of Labor - OSHA - promulgated an occupational health standard for either HCCPD or OCCP. The source of criteria for assessment of acceptable levels of HCCPD is the Recommended and Proposed Threshold Limit Values (TLV's) and Their Supporting Documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), 1977. No criteria was recommended for OCCP. These recommendations are based on the most current state of knowledge concerning the toxicity of HCCPD and are designed to protect individuals occupationally exposed to HCCPD on an 8-hour per day, 40-hours per week basis over a normal working lifetime. The ACGIH recommends an 8-hour Time-Weighted Average (TWA) exposure of 10 ppb. The ACGIH also proposes a tentative value termed a "Short Term Exposure Limit" (STEL) of 30 ppb. It is defined as the maximal concentration to which workers can be exposed for a period up to 15 minutes. The level was established on the premise that it is sufficiently low to prevent the characteristic irritation caused by HCCPD. It is based on limited exposure data and does not give consideration to chronic effects of exposure.

b. Toxicological Properties

Very little is known about the toxicological effects of HCCPD, and the available toxicity information on OCCP is virtually non-existent. The chemical structures of HCCPD and OCCP are shown in Figure 3. Hexachlorocyclopentadiene has been reported as being a pale yellow, dense liquid (specific gravity of 1.7 at 25° C) with a vapor pressure of 0.08 mm Hg at 25° C, a vapor density of 9.4 (air = 1), and a boiling point of 239° C.<sup>5</sup>

Reported human experience with HCCPD has been limited over the past twenty years. Human experience has confirmed its irritant characteristics though there are no known cases of illness or injury attributable to inhalation, ingestion, or cutaneous exposure. Treon et al.,<sup>6</sup> detected a faint odor at 0.15 ppm where the compound was present in an inhalation chamber. A more pronounced and somewhat pungent odor was noted when the compound was present in the concentration of 0.03 ppm. Krynitsky et al.,<sup>7</sup> reported experiencing a pungent odor from HCCPD formed from the pyrolysis of OCCP; the airborne concentration of HCCP was not measured. Krynitsky described the odor as being reminiscent of naphthalene.

Hexachlorocyclopentadiene produces systemic toxicity of unknown mechanism in animals via inhalation, ingestion, and dermal exposure. Degenerative changes in the brain, heart, adrenals, liver, kidney, and lungs are observed in severely poisoned animals by all routes of administration. The toxic effects of HCCPD to mice was shown to be responsible for the toxicity of early preparations of chlordane.<sup>8,9</sup> This has long been eliminated by more complete removal of unreacted ingredients, chief among which was HCCPD. Representative data from Treon's paper,<sup>6</sup> which provides the major portion of the available toxicological information on HCCPD, is presented below:

1. Acute Vapor Exposure:

The maximal exposures survived by guinea pigs were 0.25 hours at 20.2 ppm, 1 hour at 7.2 ppm, 3.5 hours at 3.1 ppm, and 7 hours at 1.5 ppm. Maximal exposures survived by rats were 0.25 hour at 20.2 ppm, 0.5 hour at 7.2 ppm, 1 hour at 3.1 ppm, and 7 hours at 0.33 ppm. Exposures to the vapors also gave use to such severe signs of irritation of the mucous and respiratory membranes as lacrimation, salivation, gasping respiration. Very high concentrations also caused tremors in some animals.

2. Chronic Vapor Exposure:

Guinea pigs, rabbits, and rats survived at 0.15 ppm given in 150 separate 7-hour exposures over 216 days. Guinea pigs survived at 0.34 ppm on the same exposure schedule, but rats and mice died after only 30 of the 7-hour exposures.

3. Oral Exposure:

The approximate lethal dose by single administration of 93.3% purity was between 420 and 620 mg/kg for rats and rabbits. Oral administration induced diarrhea, lethargy, and retarded respiration. Rabbits and rats given lethal doses exhibited diffuse degenerative changes in the brain, heart, liver, and adrenal glands. The lungs showed severe hyperemia and edema.

4. Skin:

The minimum lethal dose applied to rabbit skin was 430 to 610 mg/kg. Such contact resulted in severe skin damage, characterized by hyperemia, hemorrhages, edema, and necrosis of the skin.

No data are available on the carcinogenicity, mutagenicity, or teratogenicity of HCCPD.

Hexachlorocyclopentadiene shows unusual fungicidal and germicidal activity toward many fungi and bacteria, and good in vitro effects against many animal pathogens at very low concentrations.<sup>10</sup> The compound's germicidal properties in sewage were compared to chlorine by Cole in 1954.<sup>11</sup> He found that HCCPD was more effective in reducing total bacterial, coliform and Salmonella typhosa counts. (Salmonella typhosa is a pathogenic organism found in water.) Hyman<sup>12</sup> reported that HCCPD is herbicidal to small plants (algae) and small grasses and weeds; however, Yowell<sup>13</sup> reported that it is not injurious to plants.

## VI. RESULTS AND DISCUSSION

### 1. Environmental\*

A. Basically, the clean-up effort had three overlapping phases:  
1. Reopening of the treatment plant buildings. 2. Decontamination of the major contamination areas, then the remaining facilities. 3. Decontamination of the Ohio River Interceptor Sewer and Diversion Structure.

#### 1. Reopening of the Treatment Plant Buildings

Prior to recommending that the plant buildings be reopened to MSD personnel without requiring use of personal protective equipment, each was thoroughly evaluated for the presence of HCCPD and OCCP. Because of proximity to the major contamination area (Screen and Grit Buildings) and high occupancy of the Administration and Main Equipment Buildings, they were re-evaluated after clean-up activities began to assure that re-contamination was not occurring.

Stationary samplers operating at 50 cc/min were strategically positioned within each building to obtain 6.5 to 8.5-hour composite air samples. The sampling results are summarized in Tables 2, 3, and 4. The airborne concentrations of HCCPD and OCCP were all <3 and 2 ppb, respectively. Due to the proximity of the Administration Building (within 100 feet of the Screen & Grit Building, and Grit Loading Buildings) surface wipe samples were also collected. Nine wipe samples were collected using Whatman filter paper and de-ionized water, each covering an area of approximately 100 cm<sup>2</sup>. The wipe pads were extracted with 2 ml of carbon disulfide, sonified for 2-hours, and analyzed using the gas chromatograph-flame ionization detector method outlined in Appendix II. Extraction of spiked pads indicated a recovery of >95%. No HCCPD was detected on the wipe samples with a detection limit of 40 ug/wipe sample (Table 5).

#### 2. Decontamination of Major Contamination Areas and the Remaining Facilities

Decontamination of the major contamination areas (Screen & Grit Building, and Grit Loading Buildings) involved (a) removal of the contaminated screenings and grit, and (b) wash-down of the contaminated equipment using high pressure water (approximately 2000 psi).

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\* The samples obtained during the first several weeks were used for methods development. Therefore, the sampling and analytical procedures and resultant data are not presented.

The workers wore full-suit air line respirators consisting of a 0.006 gauge polyvinyl chloride slipover jacket with sealed-on hood and detachable gloves, and trousers with sealed-on boots. The breathing air first filtered through a \*Catalite® Air Purifier was provided by an oil-lubricated compressor. The Catalite® filter removed solid and liquid particles, as well as carbon monoxide and various organic compounds. Although, the air purification system had these capabilities, the breathing air was monitored for carbon monoxide and total hydrocarbons with an \*Ecolyzer® and \*Century Organic Vapor Analyzer®, respectively. The breathing air was also monitored for the percent oxygen. The monitoring showed that the breathing air contained an average of 20.8% oxygen, 1.9 ppm carbon monoxide, and 2.5 ppm total hydrocarbons.

During both grit removal and equipment/building wash-down operations, the workers breathing zone exposures to HCCP and OCCP were concurrently monitored. The concentrations of HCCP and OCCP measured inside the protective suits are shown in Tables 6 and 7, respectively. No worker was exposed to HCCP above the 10 ppb 8-hour threshold limit value; however, the samples did show HCCP and OCCP contamination. Most likely these exposures occurred when the personal protective equipment was being put-on and taken-off. None of the workers reported any symptoms of eye or upper respiratory tract irritation suggestive of acute toxicity.

The noise levels within the protective suits, generated primarily by improper positioning of the air supply lines, were monitored with \*Du Pont audio-dosimeters. The cumulative measurements showed that the workers were being exposed to noise levels (90-92 dBA 8-hour TWA) in excess of the 90 dBA current federal occupational health standard. Consequently, it was recommended that the workers wear hearing protectors.

During all other plant clean-up operations, the workers wore either a NIOSH-approved half or full-face chemical cartridge respirator. Depending on the nature of the exposure they also wore disposable plastic coveralls or 2-piece rubber suits, gloves, rubber boots, or whatever personal protective equipment was necessary to prevent skin contact with the contaminants.

The concentrations of HCCPD and OCCP measured during clean-up of the a grit channel and several final settling tanks are presented in Tables 8 and 9, respectively. During these activities the workers wore half-face chemical cartridge respirators. An attempt was made to monitor worker exposure during wash-down of other settling tanks and the shock chlorination basin. However, the samples were voided because of high moisture due to rainy conditions that existed during sampling.

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\*Mention of commercial names does not constitute endorsement by the National Institute for Occupational Safety and Health.

### 3. Decontamination of the Ohio River Interceptor and Diversion Structure

Probably the most potentially hazardous phase of the clean-up effort involved decontamination of the 11' semi-elliptical Ohio River Interceptor (ORI). The ORI is a 2750' main artery which controls approximately 90% (90-95 million gallons of wastewater) of the daily flow to the treatment plant. The decontamination effort extended from May 3 through May 28, 1978.

The strategy employed to decontaminate the sewer involved using tractors to sequentially push the sewage to the influent chamber for removal by a crane for packaging into 6 cubic yard disposable steel containers and ultimate disposal in a Wilsonville, Illinois landfill. Gravley® tractors with rubber blades modified to fit the contour of the sewer were first used. However, their use was aborted because of the small amount of material that could be pushed and the resulting length of sewer that could be cleaned per day. Subsequently, men driven Bobcat® and Caterpillar® tractors with 7' wide rubber blades modified to fit the contour of the sewer used. The tractors effectively cleaned an average of approximately 100 linear feet of sewer per 24-hours; two 12-hour shifts.

A combination of ventilation and proper use of personal protective equipment controlled the workers exposure to HCCPD and OCCP during decontamination of the ORI. The ORI was ventilated by an approximately 30,000 cfm axial flow propeller fan. The fan maintained an average air flow throughout the sewer of approximately 150 linear feet per minute. The fan was re-positioned at the various manholes along the length of the sewer to obtain maximum ventilation at the main work area, i.e. as the clean-up progressed from the influent chamber towards the diversion structure the fan was re-positioned accordingly. The personal protective equipment worn by each worker included a full-face chemical cartridge respirator, which was changed every 4 hours or sooner if contaminant breakthrough occurred as indicated by eye or upper respiratory tract irritation or odor detection; disposable plastic cover-alls taped at the neck and wrists; disposable plastic gloves; and rubber hip boots. This equipment was effectively used until May 23. On May 23 without notifying NIOSH, MSD decanted the water from an anaerobic digester resulting in the unexpected introduction of hydrogen sulfide gas into the ORI. The hydrogen sulfide gas was drawn from the 52" by-pass chamber into the adjacent influent chamber and up through the ORI by the ventilating fan. Approximately 1 hour after worker evacuation from the ORI, a NIOSH team member wearing a continuous flow full-face respirator measured up to 70 ppm hydrogen sulfide gas in the influent chamber. By comparison, NIOSH recommends a ceiling concentration of 10 ppm.<sup>14</sup> Because of this incident, NIOSH recommended that the decontamination effort be immediately suspended until a respiratory protection system, effective against HCCPD, OCCP, hydrogen sulfide, or any other noxious compounds, could be developed and field tested.

The new system was an open-circuit self contained breathing apparatus. It consisted of a Survivair® respirator with the breathing supplied by an approximately 350 cubic foot 2400 psi cylinder attached to the tractor. (The pressure gauges were readily visible to the tractor operator.) Surface testing of the system, simulating the underground working procedures showed that an average of 1000 psi was required per 2 hours of work. Therefore, based on this testing, NIOSH recommended that the worker begin his egress with 1000 psi of air remaining. In the event of system failure, each tractor was equipped with a full-face chemical cartridge respirator. Surface testing showed that each worker, with his eyes closed, could remove the Survivair® respirator system and put on the reserve respirator within 12 seconds. Thus, this combination respiratory protection system was adopted and successfully used for the remainder of the decontamination effort.

The work area concentrations of HCCPD and OCCP measured during decontamination of the ORI are presented in Tables 10-12. The data contained in Tables 10-12 is summarized in Table 13. No environmental sampling was conducted during the several days required to decontaminate the Diversion Structure.

B. Following the clean-up of the ORI and the Diversion Structure, operations at the plant resumed under normal surveillance. Work area concentrations of HCCPD and OCCP were measured in the primary treatment area and in some associated buildings with approximately 50 million gallons of wastewater per day passing through the treatment plant. The sampling results are contained in Table 14. Other than the samples directly associated with the Screen and Grit Building, significantly high concentrations of airborne HCCPD and OCCP were not found. Based on these results, NIOSH rescinded its recommendation that respiratory protection be worn in all areas of plant excluding the Screen & Grit Building and the areas immediately associated with it. Until the airborne concentrations of HCCPD were below the prescribed threshold limit value, minimum respiratory protection provided by a half-face respirator was recommended. MSD technicians trained by NIOSH in the appropriate sampling and analytical methods conducted all subsequent environmental sampling. To assist MSD in this responsibility, an environmental surveillance program was prepared and presented by NIOSH to MSD technical and management personnel on June 14, 1977.

## 2. Medical

### A. Follow-up Questionnaire

Usable responses were obtained from 182 individuals including 23 females and 159 males with an average age of 30 years (range of 18 to 63 years).

The frequency of symptoms among the 182 employees who returned the questionnaire is shown in Table 15. In decreasing order of frequency, these symptoms included eye irritation, headache, fatigue, chest discomfort, sore throat, cough, nausea, and skin rash. These symptoms were relatively persistent; all except for eye irritation and sore throat were still present in 25-45% of the symptomatic employees after 6 weeks.

The frequency of symptoms by department or area of the plant is shown in Table 16. (The department or area listed is that as reported on the questionnaire.) Symptoms occurred in workers throughout the plant. However, the number of symptoms reported by maintenance department personnel were consistently higher than those by all other persons.

## B. Review of Plant Medical Records

A total of 90 MSD employees were seen by the plant physician during mid-March 1977 to May 10, 1977. The workers either went directly or were referred to him from an hospital emergency room for follow-up. The medical records revealed the following:

a. The symptoms reported were similar to those reported on the NIOSH and CDC questionnaires (Table 17). Fatigue, headache, and mucous membrane irritation predominated. Respiratory and skin complaints were also reported.

b. Some of the workers reported several symptoms which were not reported on the NIOSH and CDC questionnaires. Seven of the 90 persons reported transient memory loss, ranging from a few minutes to a few days. These episodes are probably not a true amnesia, but rather a transient state of confusion. A few workers allegedly "heavily-exposed" to the chemicals, reported a feeling of burning in the face, puffy eyes, burning in the hands and feet. The plant physician found no one with any objective neurologic signs, but he did find 7 persons with a rash on exposed areas of face and arms.

c. Some workers reported respiratory tract symptoms (12 with cough; 11 with chest discomfort). Twenty-eight persons, including those with respiratory symptoms, received chest X-rays. Essentially all of these chest X-rays were normal, except for one with some questionable basilar atelectasis. Sixteen persons received blood gas determinations, none of which showed an elevated  $pCO_2$  or a  $pO_2$  below 70 mmHg. Pulmonary function tests were done on 22 individuals. No significant pattern of abnormalities was seen.

d. Pulmonary function testing (PFT) was completed through MSD on members of the clean-up crew to screen out persons who had significant respiratory impairment or who could not tolerate wearing a respirator. The PFT's were reviewed and persons were determined as capable of wearing a respirator by a private physician. The PFT results were not reviewed by NIOSH physicians.

e. Cholinesterase levels on 27 workers were all negative. Several workers had elevated liver function tests; these were mainly minor elevations of lactic dehydrogenase (LDH) and alkaline phosphatase, which are difficult to interpret (Table 18). More specific liver function tests, such as serum glutamic oxalacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) were elevated in 3 persons. Six elevations of bilirubin, 2 elevations of serum creatinine and 6 minimal elevations of proteinurias were noted. Most of the abnormalities were from the specimens collected by the CDC physician<sup>4</sup>. Since these results are from different laboratories (at least 3), they are difficult to compare. Several abnormalities in creatine phosphokinase (CPK) were recorded; this enzyme was not tested for in the NIOSH

sampling because this data was not available at the time of planning the NIOSH biological surveillance effort. The significance of these CPK elevations is uncertain, since minor trauma to muscles can cause significant elevations.

### C. Biological Monitoring Conducted by NIOSH

a. Biological monitoring of NIOSH and U.S. EPA personnel, who were actively involved in the clean-up effort, showed no significant abnormalities. Blood and urine specimens obtained from an EPA technician 4 days after being exposed (without wearing respiratory protection) to approximately 19,200 ppb HCCP and 650 ppb OCCP gave normal results. The estimated exposure period was less than 1 minute.

b. Repeat lab tests were drawn on 20 of the 23 people with abnormalities on the blood and urine tests obtained by the CDC physician immediately after the plant shut down. Three of these people continued to have persistent abnormalities in liver function tests on one or more occasions. There were no persistent urinary abnormalities.

c. Serial biological monitoring of the clean-up crew was done on five separate trips during April and May, 1977. The original plan was to do pre-exposure baseline studies and serial follow-up studies on all workers in the clean-up crew; but there were continuous changes in clean-up plans and crew members. The final result was that only 54% of the 97 clean-up crew members did have pre-exposure baseline studies done.

The results of biological monitoring on the clean-up crew are shown in Table 19. Symptoms reported by crew members were similar to those reported on the NIOSH and CDC questionnaire surveys of the plant employees exposed during March. Headache and eye irritation predominate; sore throat, fatigue, nausea, dizziness, chest discomfort, cough, and skin irritation were also reported. Additionally, to minimize the number of people exposed to chemicals and to simplify manpower supply problems, some of the clean-up crew members (particularly those involved in cleaning the ORI) worked up to 72 hours per week. The long hours certainly contributed to reports of fatigue. The NIOSH physician interviewed several crew members who reported symptoms suggestive of heat stress, especially among those working in the sun while wearing an impervious suit to prevent dermal absorption of HCCPD and OCCP.

Physical examinations on clean-up crew members were generally unrevealing except for occasional conjunctival irritation in workers wearing half-face respirators.

Of the 97 crew members tested, 18 (19%) showed some elevation of a liver function test on one or more of the five testing days. These elevations were generally small (See Table 20), but they tended to persist over several weeks once they appeared. (See Table 21). Only two of these individuals admitted to significant alcohol consumption. There was also a small number of abnormalities on renal function tests, but these tended to be very minimal and not reproducible on serial testing. Abnormalities in the complete blood count were also minor and non-reproducible.

Because of the unknown effects of exposure to the mixture of chemicals, the NIOSH medical officer requested that any worker with a "significant abnormality" on a lab test should be kept out of a high-exposure area of the plant until a repeat test came back within normal limits. Because of the difficulty in defining "normality" in lab tests, "significant abnormality" was interpreted in practice as more than about 10% above the laboratory "normal range for 95% of individuals".

As a result of this policy, 14 workers were restricted from high-exposure areas of the plant for some period of time (3 from the group of symptomatic individuals originally seen by the CDC physician; 11 from the group of workers involved in clean-up).

The lab results on clean-up workers are difficult to interpret for lack of adequate controls. Essentially all of the plant employees, including many of the clean-up workers, had been exposed previously during March, prior to the plant shutdown. Due to the general confusion caused by the variety of agencies giving medical input, and due to the limitations on time and on medical personnel available in NIOSH at the time the monitoring effort by NIOSH was essentially restricted to monitoring workers actually involved in clean-up. NIOSH's primary objective was to assure that no serious injury resulted from the clean-up effort.

Despite these problems in analysis, the data are suggestive that the exposure to the mixture of chemicals contaminating the treatment plant may be associated with some mild liver injury.

#### D. NIOSH Pathology Studies

A NIOSH veterinarian conducted two pathology studies on rats and guinea pigs treated with hexachlorocyclopentadiene. The first study involved gavaging female rats with varying doses of HCCPD; the second involved painting the male guinea pigs with the same compounds. The results of these studies are contained in Appendix IV and V, respectively.

### VII. RECOMMENDATIONS

Decontamination of the Western Outfall and Western Interceptor Sewers must be accomplished before MSD's operations can be completely back to normal. On April 5, 1978, recommendations for work procedures and practices, personal protective equipment, and environmental/medical surveillance were outlined to MSD management for use during decontamination of these contributory sewer lines (Appendix III).

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Table 1

ANALYSIS<sup>1</sup> OF A SLUDGE SAMPLE OBTAINED IN THE  
SCREEN AND GRIT BUILDING ON APRIL 2, 1977

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
LOUISVILLE, KENTUCKY

Compound <sup>2</sup>	Concentration - % by weight
Octachlorocyclopentene	9
Hexachlorocyclopentadiene	4
Hexachlorobenzene	0.3
Pentachlorobenzene	0.2
Octachloronaphthalene	0.4 (estimated)
Heptachloronaphthalene	0.2 (estimated)
Hexachloronaphthalene	(not quantitated)
Mirex	0.007 (estimated)

<sup>1</sup> Analysis was conducted by the U.S. Food and Drug Administration, Division of Chemical Technology, Chemical Industry Practices Branch.

<sup>2</sup> The sample was analyzed using gas chromatography interphased with mass spectroscopy for positive identification of each compound.

Table 2  
 WORK-AREA CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
 MEASURED IN THE ADMINISTRATION BUILDING  
 MORRIS FORMAN WASTEWATER TREATMENT PLANT  
 LOUISVILLE, KENTUCKY  
 1977

Sample Date	Sample No.	Sample Description	Sampling Period	Sample Volume liters	Airborne Concentration - ppb <sup>1</sup>		
					HCCPD	OCCP	
4/22-23	CR-064	3rd Floor: Outside Elevator	1634 - 0007	19	<0.5	<0.8	
4/23	CR-072	" " " "	0820 - 1625	25	1	<0.6	
4/22-23	CR-065	3rd Floor: Center Main Office	1634 - 0008	18	<0.5	<0.8	
4/23	CR-073	" " " " "	0821 - 1625	30	<0.3	<0.5	
5/03	CR-121	" " " " "	0834 - 1545	21	<0.4	<0.7	
5/12	CR-154	" " " " "	1125 - 1730	20	<0.4	<0.7	
4/22-23	CR-061	Room 226 : Industrial Waste Laboratory	1630 - 0008	19	<0.5	<0.8	
4/23	CR-069	" " " " "	0822 - 1620	21	2	2	
5/03	CR-119	" " " " "	0830 - 1536	17	<0.5	<0.9	
4/22-23	CR-063	Room 209: Quality Control Lab	1632 - 0007	19	2	2	
4/23	CR-071	" " " " "	0823 - 1621	20	3	<0.7	
5/03	CR-120	" " " " "	0832 - 1540	24	<0.4	<0.6	
4/22-23	CR-062	Hallway between Rooms 226 and 209	1631 - 0008	18	<0.5	<0.8	
4/23	CR-070	" " " " "	0822 - 1620	22	<0.4	<0.7	
4/22-23	CR-068	1st Floor: Vending Machine Area	1655 - 0026	17	1	2	
4/23	CR-076	" " " " "	0818 - 1620	22	<0.4	<0.6	
4/22-23	CR-067	Elevator Shaft: Bottom	1651 - 0025	24	<0.4	<0.6	
4/23	CR-075	" " " " "	0823 - 1615	23	1	<0.6	
4/22-23	CR-066	Room 113: Stairwell	1650 - 0026	18	<0.5	<0.8	
4/23	CR-077	" " " " "	0900 - 1620	18	<0.5	<0.8	
4/23	CR-074	Room 113: Between Air Units 1 & 2	0822 - 1615	22	1	0.7	
4/27	CR-112	" " " " " " "	0845 - 1514	15	<0.6	<1.0	
5/03	CR-118	" " " " " " "	0825 - 1535	16	<0.6	<0.9	
5/11-12	CR-149	Room 104	1800 - 0030	19	<0.6	<0.9	
Environmental Criteria					10	None Established	

<sup>1</sup>Denotes parts of contaminant per billion parts of contaminated air sampled by volume.

Table 3  
 WORK-AREA CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
 MEASURED IN THE MAIN EQUIPMENT BUILDING  
 MORRIS FORMAN WASTEWATER TREATMENT PLANT  
 LOUISVILLE, KENTUCKY  
 1977

Sample Date	Sample No.	Sample Description	Sampling Period	Sample Volume liters	Airborne Concentration - ppb <sup>1</sup>		
					HCCPD	OCCP	
4-15	CR-001	Room 614: Vacuum Filtration Area	0843 - 1543	21	<0.4	<0.7	
"	CR-015	" " " " " "	1544 - 2354	25	<0.4	<0.6	
4-27	CR-099	" " " " " "	0740 - 1445	16	<0.6	<0.9	
"	CR-100	Room 605: " " " "	0740 - 1449	20	<0.5	<0.7	
"	CR-102	Room 527: Restroom Area	0800 - 1456	15	<0.6	<1.0	
4-15	CR-001	Room 512: Sludge Well Area	0839 - 1539	24	<0.4	<0.6	
"	CR-016	" " " " " "	1540 - 2352	21	<0.4	<0.7	
4-27	CR-101	" " " " " "	0750 - 1455	19	<0.5	<0.8	
"	CR-111	Room 432: Warehouse	0835 - 1459	15	<0.6	<0.1	
4-15	CR-003	Room 415: Sludge Pump Area	0848 - 1547	21	<2.6	<2.7	
"	CR-017	" " " " " "	1548 - 2359	33	<0.3	<0.4	
4-27	CR-103	" " " " " "	0802 - 1458	19	<0.5	<0.8	
4-15	CR-006	Room 410: Compressor Area	0850 - 1550	24	<0.4	<0.6	
"	CR-014	" " " " " "	1551 - 2359	27	<0.3	<0.5	
4-15	CR-004	Room 336: Face Plenum of Intake Air Handlers	0856 - 1557	20	<2.8	<2.9	
"	CR-018	" " " " " "	1600 - 2330	13	<0.7	<0.2	
4-27	CR-104	" " " " " "	0804 - 1450	19	<0.5	<0.7	
4-15	CR-008	Room 328: Locker Room	0858 - 1554	17	<0.5	<0.8	
4-27	CR-105	Room 311: East side of room	0805 - 1500	16	<0.6	<0.9	
"	CR-106	Room 311: West side of room	0810 - 1501	15	<0.6	<0.9	
"	CR-107	3rd Floor: Incineration Area	0813 - 1505	16	<0.6	<0.9	
4-15	CR-007	200 Level: Sludge Thickeners	0901 - 1610	23	<2.3	<2.4	
"	CR-013	" " " " " "	1611 - 2359	26	<0.4	<0.6	
4-27	CR-109	" " " " " "	0818 - 1509	21	<0.4	<0.7	
4-15	CR-009	Base Level: Zimpro Reactor Bag	0837 - 1603	22	<2.5	<2.6	
"	CR-011	" " " " " "	1603 - 2356	24	<0.4	<0.6	
4-27	CR-108	" " " " " "	0816 - 1504	13	<0.7	<1.1	
4-15	CR-005	Face of tunnel to Aeration Service Bldg.	0903 - 1613	20	<0.5	<0.7	
4-27	CR-110	" " " " " "	0820 - 1505	17	<0.5	<0.8	
4-15	CR-012	Ash Loading Area	1620 - 2359	27	<0.3	<0.5	
4-27	CR-096	OGA: Compressor Room	0805 - 1515	19	<0.5	<0.8	
Environmental Criteria					10	None Established	

<sup>1</sup> Denotes parts of contaminant per billion parts of contaminated air sampled by volume.

Table 4  
 WORK-AREA CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
 MEASURED IN DIFFERENT BUILDINGS WITHIN THE WASTEWATER TREATMENT FACILITY

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
 LOUISVILLE, KENTUCKY  
 1977

Sample Date	Sample No.	Sample Description	Sampling Period	Sample Volume Liters	Airborne Concentration - ppb <sup>1</sup>		
					HCCPD	OCCP	
4-15	CR-010	Dewatering Bldg.: Basement	0831 - 1625	21	<2.7	<2.8	
5-02	CR-113	" " "	1035 - 1548	11	<0.8	<1.3	
"	CR-114	" " "	1038 - 1551	14	2	<1.0	
"	CR-115	" " "	1040 - 1550	15	1	<0.9	
"	CR-116	Digestion Control Bldg.: Basement	1042 - 1553	16	1	<0.9	
"	CR-117	" " "	1043 - 1554	13	1	<1.1	
4-26	CR-086	North Pumping Station: Basement	0730 - 1458	16	<0.6	<0.9	
"	CR-088	South Pumping Station: Basement	0734 - 1500	17	<0.5	<0.9	
"	CR-087	Center of tunnel between N and S Pumping Stations	0733 - 1459	12	<0.8	<1.2	
"	CR-089	Service Blower Bldg.: Basement	0736 - 1501	16	<0.6	<0.9	
"	CR-090	Aeration Service Bldg.: Basement	0737 - 1505	23	<0.4	<0.6	
"	CR-091	Center of tunnel between Aeration Service Bldg. and Main Equipment Bldg.	0710 - 1400	20	<0.5	<0.7	
"	CR-092	Center of tunnel between Aeration Service Bldg. and Sludge Pumping Bldg.	0744 - 1506	12	<0.8	<1.2	
"	CR-093	Sludge Pumping Bldg.: Basement	0748 - 1508	17	<0.5	<0.9	
"	CR-094	Effluent Pumping Bldg.: 2nd level	0750 - 1511	18	<0.5	<0.8	
"	CR-095	Stormwater Pump Station	0800 - 1514	19	<0.5	<0.8	
Environmental Criteria					10	None Established	

<sup>1</sup>Parts of contaminant per billion parts of contaminated air sampled by volume.

Table 5

RESULTS OF SURFACE WIPE SAMPLES  
OBTAINED IN THE ADMINISTRATION BUILDING  
MORRIS FORMAN WASTEWATER TREATMENT PLANT  
LOUISVILLE, KENTUCKY

APRIL 12, 1977

<u>Sample No.</u>	<u>Sample Description</u>	<u>Hexachlorocyclopentadiene</u>
S-1	3rd Floor: Main Office Area - Desk	None Detected
S-2	" " " " " "	" " "
S-3	3rd Floor: Main Office Area - Typewriter	" " "
S-4	2nd Floor: Laboratory Desk	" " "
S-5	" " " " " "	" " "
S-6	2nd Floor: Window Sill	" " "
S-7	1st Floor: Cafeteria Table	" " "
S-8	" " " " " "	" " "
S-9	" " " " " "	" " "

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\* Limit of detection was 40 µg/wipe sample

Table 6

\*PERSONAL BREATHING ZONE CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
MEASURED IN THE GRIT LOADING, AND SCREEN & GRIT BUILDINGS DURING GRIT REMOVAL

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
LOUISVILLE, KENTUCKY  
1977

Sample Date	Sample No.	Sample Description <sup>1</sup>	Sampling Period	Sample Volume liters	Airborne Concentration - ppb <sup>2</sup>		
					HCCPD	OCCP	
4-17	CR-022	PBZ-GLB: Maintenance Mechanic	1257 - 1322 1459 - 1533	6	<1.5	<2.4	
4-18	CR-023	PBZ-SGB: Equipment Operator	1528 - 1919	12	3	<1.2	
"	CR-024	PBZ-SGB: Equipment Operator	2044 - 2222 1536 - 1907	16	7	<0.9	
4-19	CR-027	PBZ-GLB: Loading Operator	2043 - 2220 0805 - 0905 1008 - 1120 1243 - 1519	13	<0.7	<1.1	
"	CR-029	PBZ-SGB: Equipment Operator	0806 - 0909 1007 - 1120	10	<0.5	<0.8	
"	CR-035	PBZ-SGB: Equipment Operator	1255 - 1515	4	<2.3	<3.7	
"	CR-036	PBZ-GLB: Loading Operator	1645 - 1803 1646 - 1805 2045 - 2253	10	8	2	
4-20	CR-037	PBZ-SGB: Equipment Operator	0005 - 0119 0230 - 0440 0600 - 0740	12	6	4	
"	CR-038	PBZ-GLB: Loading Operator	0006 - 0120 0235 - 0441 0600 - 0741	14	1	<1.0	
"	CR-041	PBZ-SGB: Equipment Operator	0747 - 0857 0950 - 1112	14	5	<1.1	
"	CR-042	PBZ-GLB: Loading Operator	1303 - 1359 0749 - 0851 0948 - 1113 1317 - 1405	8	7	<1.9	
"	CR-048	PBZ-SGB: Equipment Operator	1646 - 1715	12	<0.8	<1.2	
"	CR-049	PBZ-GLB: Loading Operator	1858 - 2234	7	<1.4	<2.2	
Environmental Criteria					10	None Established	

<sup>1</sup>PBZ-GLB denotes personal breathing zone sample in the Grit Loading Building and PBZ-SGB denotes personal breathing zone sample in the Screen and Grit Building.

<sup>2</sup>Parts of contaminant per billion parts of contaminated air sampled by volume.

\*Concentration was measured underneath the protective vinyl suit in the breathing zone of the worker.

Table 7  
 PERSONAL BREATHING ZONE CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
 MEASURED INSIDE THE PROTECTIVE SUITS WORN BY PERSONS INVOLVED WITH THE HIGH PRESSURE WATER WASHDOWN OF THE SCREEN AND GRIT BUILDING  
 MORRIS FORMAN WASTEWATER TREATMENT PLANT  
 LOUISVILLE, KENTUCKY  
 1977

<u>Sample Date</u>	<u>Sample No.</u>	<u>Sampling Period</u>	<u>Sample Volume liters</u>	<u>Airborne Concentrations - ppb<sup>1</sup></u>	
				<u>HCCPD</u>	<u>OCCP</u>
4-22	CR-058	0945 - 1117 1225 - 1534	12	<0.8	4
4-22	CR-059	0946 - 1122 1225 - 1540	15	<0.6	<0.9
4-22	CR-060	0947 - 1120 1226 - 1540	13	<0.7	<1.1
4-23	CR-078	0850 - 1145 1248 - 1600	18	<0.5	<0.8
4-23	CR-079	0851 - 1145 1253 - 1601	9	1.0	<1.8
4-23	CR-080	1045 - 1145 1252 - 1604	8	<1.0	<1.4
4-25	CR-081	1245 - 1401 1438 - 1534	32	<0.3	<0.4
4-25	CR-082	1308 - 1405 1438 - 1537	23	<0.4	<0.6
4-25	CR-083	1246 - 1402	29	<0.3	<0.5
<u>Environmental Criteria</u>				10	None Established

<sup>1</sup>Parts of contaminant per billion parts of contaminated air sampled by volume.

Table 8

\*CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
MEASURED DURING GRIT CHANNEL CLEAN-UP

Sample Date	Sample No.	Sample Description	Sampling Period	Sample Volume liters	Airborne Concentration - ppb <sup>1</sup>	
					HCCPD	OCCP
4-26	CR-097	Grit Channel 4: Washdown with low pressure water	1246 - 1325	9	<1	<1.5
5-10	CR-142	Grit Channel 1: Shoveling of grit and sludge into drums	1330 - 1420 1440 - 1530	23	52	21
"	CR-143	" " " " " " " " " " "	1330 - 1420 1433 - 1530	21	40	18
Environmental Criteria					10	None Established

<sup>1</sup>Parts of contaminant per billion parts of contaminated air sampled by volume.  
\*Sample taken on worker outside of respirator.

Table 9

\*CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
MEASURED DURING WASHING OF FINAL SETTLING TANKS WITH LOW PRESSURE WATER

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
LOUISVILLE, KENTUCKY  
1977

Sample Date	Sample No.	Sample Description	Sampling Period	Sample Volume liters	Airborne Concentration - ppb <sup>1</sup>	
					HCCPD	OCCP
4-20	CR-045	Battery C: Tank C-3	1249 - 1515	9	4	<1.5
"	CR-045	" " " "	1252 - 1515	7	<1.3	<2.0
"	CR-047	Battery C: Tank C-1	1254 - 1515	5	7	<3.1
4-21	CR-055	Battery C: Tank C-3	0840 - 1435	12	<0.8	<1.2
"	CR-056	" " " "	0849 - 1435	11	<0.8	<1.3
Environmental Criteria					10	None Established

<sup>1</sup>Parts of contaminant per billion parts of contaminated air sampled by volume.

\*Sample taken on worker outside of respirator.

Table 10  
 CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
 MEASURED DURING REMOVAL OF CONTAMINATED GRIT FROM THE INFLUENT CHAMBER AND SEMI-ELLIPTICAL OHIO RIVER INTERCEPTOR SEWER  
 MORRIS FORMAN WASTEWATER TREATMENT PLANT  
 LOUISVILLE KENTUCKY  
 1977

Sample Date	Sample No.	Sample Description <sup>1</sup>	Sampling Period	Sample Volume liters	Airborne Concentration - ppb <sup>2</sup>		
					HCCPD	OCCP	
5-03	CR-123	P: Building of Influent Chamber Dam	1328 - 1509	11	277	43	
"	CR-122	WA: Building of Influent Chamber Dam	1200 - 1508	17	1183	104	
5-04	CR-125	F: Working area around Station 2 + 00	0110 - 0235	6	998	68	
"	CR-126	" " " " " "	0305 - 0340				
"	CR-127	" " " " " "	0111 - 0235	6	21	3	
"	CR-128	" " " " " "	0305 - 0235				
"	CR-128	" " " " " "	0113 - 1500	10	371	36	
"	CR-129	P: Working area around Station 6 + 00	0115 - 0315	9	248	26	
"	CR-130	" " " " " "	0815 - 1820	30	3727	233	
"	CR-131	" " " " " "	0844 - 0905	7	491	33	
"	CR-131	" " " " " "	1240 - 1420	14	1478	108	
"	CR-132	" " " " " "	1502 - 1745				
"	CR-132	" " " " " "	1241 - 1420	12	2195	325	
"	CR-132	" " " " " "	1502 - 1605				
"	CR-133	WA Influent Chamber	1607 - 1745				
5-09	CR-134	P: Working area around Station 10 + 00	1816 - 2005	6	4286	316	
"	CR-134	" " " " " "	1140 - 1306	7	1275	140	
"	CR-137	WA: Attached to tractor operated by person wearing Sample CR-134	1425 - 1546				
"	CR-137	" " " " " "	1400 - 1306	18	168	17	
"	CR-136	P: Working area around Station 10 + 00	1425 - 1805				
"	CR-136	" " " " " "	1145 - 1305	11	467	60	
"	CR-136	" " " " " "	1420 - 1605				
"	CR-135	WA: Attached to tractor operated by person wearing Sample CR-136	1640 - 1710				
5-10	CR-138	P: Working area around Station 12 + 00	1145 - 1805	16	307	38	
"	CR-138	" " " " " "	0830 - 1034	14	2760	80	
"	CR-139	WA: Attached to tractor operated by person wearing Sample CR-138	1100 - 1150				
"	CR-139	" " " " " "	1259 - 1510				
"	CR-140	P: Working area around Station 12 + 00	1540 - 1641				
"	CR-140	" " " " " "	0830 - 1740	25	3066	250	
"	CR-140	" " " " " "	0835 - 1126	21	553	49	
"	CR-141	WA: Attached to tractor operated by person wearing Sample CR-140	1305 - 1510				
"	CR-141	" " " " " "	1540 - 1626				
"	CR-141	" " " " " "	0835 - 1740	28	134	22	
Environmental Criteria					10	None Established	

<sup>1</sup>P denotes sample taken on worker outside of respirator; WA denotes work-area.

<sup>2</sup>Parts of contaminant per billion parts of contaminated air sampled by volume.

Table 11  
 CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
 MEASURED DURING REMOVAL OF CONTAMINATED GRIT FROM THE SEMI-ELLIPTICAL OHIO RIVER INTERCEPTOR  
 MORRIS FORMAN WASTEWATER TREATMENT PLANT  
 LOUISVILLE, KENTUCKY  
 1977

Sample Date	Sample No.	Sample Description <sup>1</sup>	Sampling Period	Sample Volume liters	Airborne Concentration - ppb <sup>2</sup>	
					HCCPD	OCCP
5-11	CR-145	P: Working area around Station 14 + 50	1230 - 1430 1540 - 1641 1915 - 2035	13	3185	241
"	CR-146	WA: Attached to tractor operated by person wearing Sample CR-145	1230 - 2050	12	1972	183
"	CR-147	P: Working area around Station 14 + 50	1225 - 1437 1540 - 1626	18	2836	213
"	CR-148	WA: Attached to tractor operated by person wearing Sample CR-147	1915 - 2100	25	2102	186
"	CR-150	WA: Sampler 24" below manhole Station 14 + 50 in Haze	2040 - 2206	17	7083	446
5-12	CR-152	WA: Attached to tractor operated around Station 16 + 00	0035 - 0700	19	494	67
"	CR-153	WA: Attached to tractor operated around Station 16 + 00	0040 - 0700	24	2402	215
"	CR-155	WA: Attached to tractor positioned at Station 17 + 00 in Haze	0400 - 0545	22	11801	1488
"	CR-156	WA: Attached to tractor positioned at Station 17 + 00 in Haze	0400 - 0545	23	11127	1343
"	CR-157	WA: Sampler 24" below manhole Station 14 + 50	1330 - 1450	27	813	89
5-17	CR-158	P: Working area around Station 16 + 00	0130 - 0400 0630 - 0730	7	960	126
"	CR-159	WA: Attached to tractor operated by person wearing Sample CR-158	0130 - 0945	23	1057	181
"	CR-160	WA: Attached to tractor operating around Station 16 + 00	0129 - 0945	22	444	101
"	CR-161	P: Working area around Station 17 + 00	1740 - 2315	21	567	91
"	CR-162	WA: Attached to tractor working around Station 16 + 00	1742 - 2315	15	1335	203
5-18	CR-163	WA: Attached to tractor operating around Station 17 + 00	0025 - 1240	38	1286	189
"	CR-164	WA: Attached to tractor operating around Station 17 + 00	0025 - 1240	38	1934	246
"	CR-165	WA: Attached to tractor operating around Station 19 + 00	1245 - 2130	30	2170	298
"	CR-166	WA: Attached to tractor operating around Station 19 + 00	1245 - 2100	23	1968	301
"	CR-167	WA: Attached to tractor operating around Station 19 + 00	1245 - 2100	24	1431	234
Environmental Criteria					10	None Established

<sup>1</sup>P denotes sample taken on worker outside of respirator; WA denotes work-area.

<sup>2</sup>Parts of contaminant per billion parts of contaminated air sampled by volume.

Table 12  
 CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
 MEASURED DURING REMOVAL OF CONTAMINATED GRIT FROM THE SEMI-ELLIPTICAL OHIO RIVER INTERCEPTOR  
 MORRIS FORMAN WASTEWATER TREATMENT PLANT  
 LOUISVILLE, KENTUCKY  
 1977

Sample Date	Sample No.	Sample Description <sup>1</sup>	Sampling Period	Sample Volume liters	Airborne Concentration - ppb <sup>2</sup>		
					HCCPD	OCCP	
5-19	CR-168	WA: Attached to tractor operating around Station 20 + 00	0200 - 1045	22	1979	302	
"	CR-169	" " " " " " " " " "	" "	24	2128	322	
"	CR-170	P: Working area around 20 + 00	1133 - 2000	26	3833	472	
"	CR-171	" " " " " " " " " "	1140 - 2000	28	2592	346	
5-21	CR-177	WA: Attached to tractor operating around Station 22 + 00	1500 - 2050	24	1362	370	
"	CR-178	" " " " " " " " " "	" "	3	293	154	
5-22	CR-181	WA: Attached to tractor operating around Station 23 + 00	0030 - 0900	26	2042	416	
"	CR-180	" " " " " " " " " "	" "	25	292	67	
"	CR-182	" " " " " " " " " "	1400 - 1830	27	131	35	
"	CR-183	" " " " " " " " " "	2000 - 2300	"	"	"	
"	CR-183	" " " " " " " " " "	" "	25	1962	394	
5-27	CR-185	WA: Attached to tractor operating around Station 23 + 00	0150 - 0900	15	134	39	
"	CR-186	" " " " " " " " " "	0155 - 0900	29	629	179	
"	CR-187	" " " " " " " " " "	1430 - 2330	29	134	129	
"	CR-188	" " " " " " " " " "	" "	30	567	144	
5-28	CR-189	WA: Attached to tractor operating around Station 24 + 00	0001 - 0700	17	1207	228	
"	CR-190	" " " " " " " " " "	" "	19	725	168	
"	CR-192	" " " " " " " " " "	" "	21	1997	327	
"	CR-193	" " " " " " " " " "	1245 - 2200	31	1256	227	
"	CR-194	" " " " " " " " " "	" "	27	267	52	
"	CR-195	" " " " " " " " " "	1230 - 2100	31	1780	281	
"	CR-196	" " " " " " " " " "	" "	35	1410	245	
Environmental Criteria					10	None Established	

<sup>1</sup>P denotes sample taken on worker outside of respirator; WA denotes work-area.

<sup>2</sup>Parts to contaminant per billion parts of contaminated air sampled by volume.

Table 13  
 SUMMARY OF CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE AND OCTACHLOROCYCLOPENTENE  
 MEASURED DURING DECONTAMINATION OF INFLUENT CHAMBER AND OHIO RIVER INTERCEPTOR SEWER

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
 LOUISVILLE, KENTUCKY  
 1977

Chemical	Type of Sample <sup>1</sup>	Number of Samples	Average	Air Concentration-ppb <sup>2</sup>		Range
				Median		
Hexachlorocyclopentadiene	P	19	1518	960		21-3833
" " " " "	WA	41	1446	1286		131-4288
Octachlorocyclopentene	P	19	142	91		3-472
" " " " "	WA	41	185	189		17-416

<sup>1</sup> P denotes sample taken on worker outside of respirator; WA denotes work area.

<sup>2</sup> Denotes parts of contaminant per million parts of contaminated air sampled by volume.

Table 14  
 WORK-AREA CONCENTRATIONS OF HEXACHLOROCYCLOPENTADIENE (HCCPD) AND OCTACHLOROCYCLOPENTENE (OCCP)  
 MEASURED IN THE PRIMARY TREATMENT AREA AND SOME ASSOCIATED BUILDINGS WITH APPROXIMATELY 50 MG OF FLOW THROUGH THE PLANT  
 MORRIS FORMAN WASTEWATER TREATMENT PLANT  
 LOUISVILLE, KENTUCKY  
 1977

Sample Date	Sample No.	Sample Description	Sampling Period	Sample Volume liters	Airborne Concentration - ppb <sup>1</sup>		
					HCCPD	OCCP	
6-04	CR-202	Service Blower Bldg.: Time clock area	1214 - 2336	132	1	1	
"	CR-203	Outside Service Blower Bldg.: North west corner	1216 - 2337	148	.2	<.1	
"	CR-204	Attached to railing at east side of sedimentation tank 1	1218 - 2338	142	1	1	
"	CR-205	North Pumping Station: Basement	1228 - 2340	134	5	1	
"	CR-197	Influent Chamber: Surface concrete pad	1200 - 2325	149	7	3	
6-04	CR-198	Grit Loading Bldg.: Attached to bumper of truck during loading	1201 - 2327	144	3	3	
"	CR-199	Screen & Grit Bldg.: Attached to door of Grit Chamber 4	1203 - 2329	71	12	7	
"	CR-200	Screen & Grit Bldg.: Walkway in front of Bar Screen 3	1206 - 2333	140	28	18	
"	CR-201	Walkway between Grit Channels 3 & 4	1211 - 2334	145	7	5	
6-05	CR-206	100 ft. north east of Influent Chamber concrete pad	0847 - 1540	92	.3	.3	
"	CR-207	Sluice gate control in front of Screen & Grit Bldg.	0850 - 1542	84	82	6	
"	CR-208	Gate control box on Influent Chamber concrete pad	0852 - 1541	99	2	1	
"	CR-209	Screen & Grit Bldg.: Walkway in front of Bar Screen 2	0855 - 1543	86	53	18	
"	CR-210	Screen & Grit Bldg.: Attached to door of Grit Chamber 3	0905 - 1542	82	50	22	
6-05	CR-211	Walkway between Grit Channels 2 & 3	0910 - 1546	87	2	2	
"	CR-212	Attached to railing 100 ft. east of Aeration Service Bridge	0913 - 1547	92	2	3	
"	CR-213	Attached to railing 10 ft. west of Aeration Service Bridge	0917 - 1548	89	4	2	
"	CR-214	Attached to railing east side of sedimentation tank 3	0920 - 1550	85	2	3	
"	CR-215	South Pumping Station: Basement	0923 - 1551	77	.4	1	
6-05	CR-216	Attached to railing east side of sedimentation tank 1	0930 - 1552	87	1.4	<.2	
"	CR-217	Service Blower Bldg.: Basement	0940 - 1555	75	1	<.2	
"	CR-218	Grit Loading Bldg.: Steel walkway	0959 - 1558	67	12	17	
"	CR-219	Screen & Grit Bldg.: Attached to door of Grit Chamber 1	1005 - 1545	69	53	18	
Environmental Criteria					10	None Established	

<sup>1</sup>Parts of contaminant per billion parts of contaminated air sampled by volume.

Table 15

## SYMPTOMS REPORTED ON FOLLOW-UP QUESTIONNAIRE\*

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
LOUISVILLE, KENTUCKY

Symptom	% with symptoms in last 2 weeks of March**	Persistence of Symptoms** (% of those $\bar{c}$ symptoms)			
		Gone within 1 Day	Gone within 1 Week	Gone within 2 Weeks	Still present at time of survey
Headache	55%	19%	30%	18%	32%
Eye Irritation	62%	36%	23%	16%	15%
Sore Throat	30%	15%	49%	13%	18%
Cough	24%	14%	27%	16%	36%
Chest Discomfort	34%	11%	20%	21%	39%
Skin Irritation	21%	18%	18%	10%	46%
Nausea	22%	18%	23%	18%	25%
Fatigue	34%	8%	16%	24%	45%

\*Distributed and Collected last 2 weeks of May 1977

Excludes employees actively involved in cleanup, since their symptoms could relate to exposure during cleanup instead of to exposure prior to the plant shutdown.

\*\*% Persistences do not quite add to 100% due to some employee confusion about the need to fill in the questionnaire completely.

Table 16

FOLLOW-UP QUESTIONNAIRE (DISTRIBUTED MAY 15, 1977): SYMPTOMS REPORTED PRESENT IN LAST TWO WEEKS OF MARCH 1977 BY DEPARTMENT OR AREA

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
LOUISVILLE, KENTUCKY

Department	Headache	Eye Irritation	Sore Throat	Cough	Chest Discomfort and/or Short of Breath	Skin Rash	Nausea	Fatigue	Total Questionnaire Received	Total Employees in Dept.	% of employees sampled
Supervisor	4	6	4	3	2	1	2	2	9	9	100%
Primary Treatment	12	14	4	6	7	7	5	6	17	18	94%
Secondary Treatment	6	13	5	4	2	2	3	3	14	14	100%
Vacuum Filtration	10	7	3	2	7	5	5	4	16	19	84%
Incineration	5	4	2	0	1	0	0	1	6	10	71%
Pump	2	3	2	0	1	0	0	1	6	10	60%
Low Pressure Oxygen	2	4	1	2	2	2	2	3	11	13	85%
Maintenance	38	42	24	19	25	17	14	27	61	68	90%
Office/Lab/ Administration	17	16	6	6	7	4	6	10	31	32	97%
Total	96	109	51	43	55	41	38	59	177	200	89%

Table 17

SYMPTOMS REPORTED BY MSD EMPLOYEES WHO SAW PLANT  
PHYSICIAN FROM MID-MARCH 1977 TO MAY 10, 1977

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
LOUISVILLE, KENTUCKY

Symptom	Number of Persons Reporting Symptom out of 90
Fatigue	14
Dizziness	7
Cough	12
Sore Throat	10
Chest Discomfort	11
Headache	20
Nausea	7
Nasal Irritation	5
Eye Irritation	26
Skin Irritation	8 (7 with visible rash)
"Burning Face"	3
"Burning Feet"	1
"Nervousness"	8
"Tongue Numb"	2
Memory Loss	7
Loss of Appetite	1

Table 18

LABORATORY ABNORMALITIES IN PATIENTS WHO SAW PLANT PHYSICIAN  
MID-MARCH 1977 TO MAY 10, 1977

Patient #	SGOT <sup>1</sup> mU/ml	SGPT <sup>2</sup> mU/ml	Alk. <sup>3</sup> Phos. mU/ml	LDN <sup>4</sup> mU/ml	Bili. <sup>5</sup> mg%	Creat. <sup>6</sup> mg%	CPK <sup>7</sup> mU/ml	Protein <sup>8</sup> uria
1						1.4	348	
2					3.2		249	
3				232				
4					1.6			
5			125	266				+1
6								+2
7					1.4			
8		48						
9					2.6			
10								+1
11	150		115	360	2.2		1398	
12								+1
13			105					
14	70	88		245			230	+1
15							270	
16				205				
17					1.45			
18				230				+1
19					2.2			

- 1 SGOT = Serum glutamate-oxalacetate transaminase - N1 range = 7-40 mU/ml  
 2 SGPT = Serum glutamate pyruvate transaminase - N1 range = 1-40 mU/ml  
 3 Alk phos = Serum Lactate Dehydrogenase - N1 range = 30-100 mU/ml  
 4 LDH = Serum Lactate Dehydrogenase - N1 range = 100-225 mU/ml  
 5 Bili. = Total Serum Bilirubin - N1 range = 0.15-1.0 mg%  
 6 Creat = Serum Creatinine - N1 range = 0.5-1.3 mg%  
 7 CPK = Serum creatinine phosphokinase - N1 range = 55-170 mU/ml  
 8 proteinuria = protein in urine - graded 0 - 4+



Table 19 Continued

## BIOLOGICAL MONITORING OF CLEAN-UP CREW

Date	Abnormalities on Physical Exam	Significant Abnormalities on Lab Tests		
		Liver Function Test	Serum Creatinine	Urinalysis
4/8/77	Scaly skin on hands x 1	+SGOT x 2 +Alk. phos, x 1		
4/12/77	Conjunctival irritation x 1	+SGOT x 3		4 + Glucose x 1
4/20/77	None	+SGOT x 3 +Alk. phos. x 1	+creatinine x 1	
5/5/77	Conjunctival irritation x 1	+SGOT x 6 +Bili x 1 +Alk. phos. x 1	+creatinine x 1	1 + bile x 1 Trace albumin x 2
5/19/77	None	+SGOT x 9 +Bili x 1 +LDH x 1		
Total tests done		Total = 23 abnormal tests among 17 workers		

Table 20

## ABNORMALITIES IN LAB TESTS ON CLEAN-UP WORKERS

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
LOUISVILLE, KENTUCKY

Lab Test	Ranges of values	Number of Results in R. Range	Normal Range
1 SGOT - (serum glutamate- oxalacetic acid transaminase)	40-49	5	7-40 mU/ml
	50-59	1	
	60-69	4	
	70-79	0	
	80-89	1	
	90-99	1	
2 Serum alkaline phosphatase	100-109	3	30-100 mU/ml
	110-119	1	
	120-129	1	
3 Serum total Bilirubin	1.0-1.9	1	0.15-1.0 mg%
4 Serum LDSH (lactate dehydrogenase)	230-239	1	100-225 mU/ml
5 Serum creatinine	1.3-1.9	1	0.5-1.3 mg/dl

Table 21

## LIVER FUNCTION ABNORMALITIES IN CLEAN-UP WORKERS

MORRIS FORMAN WASTEWATER TREATMENT PLANT  
LOUISVILLE, KENTUCKY

Patient No.	Date of Visit						Hours spent in cleanup	Lab Abnormality result in removal from cleanup?
	4/8	4/12	4/20	5/5	5/19			
1				SGOT 46 <sup>1</sup> Bili 0.9 <sup>2</sup>		SGOT 35 Bili 1.6	40	Yes
2						Alk phos <sup>3</sup> 117	56	Yes
3				SGOT 48		SGOT 47	115	Yes
4						SGOT 66 LDH <sup>4</sup> 239	150	Yes
5				Bili 1.4			11	No
6		SGOT 51	SGOT 63	SGOT 45	SGOT 43		100	Yes
7				Alk phos 100			5	No
8				SGOT 42 Alk phos 113			80	No
9	SGOT 31		SGOT 31	SGOT 60	SGOT 63		110	Yes
10	SGOT 43 Alk phos 105		SGOT 52	SGOT 39 Alk phos 120	SGOT 39 Alk phos 129		40	Yes
11		SGOT 44					80	No
12	Alk phos 88	Alk phos 96		Alk phos 101			60	No
13				SGOT 87	SGOT 93		80	Yes
14			Alk phos 103				15	Yes
15	LDH 232		LDH 159				32	No
16					SGOT 47		108	Yes
17			SGOT 42	SGOT 46			40	No
18	SGOT 59		SGOT 54		SGOT 48		140	Yes

1 SGOT = Serum glutamate-oxaloacetate transferase in mU/ml - Normal range = 7-40 mU/ml

2 Bili = Total serum bilirubin in mg% - Normal range = 0.15-1.0 mg%

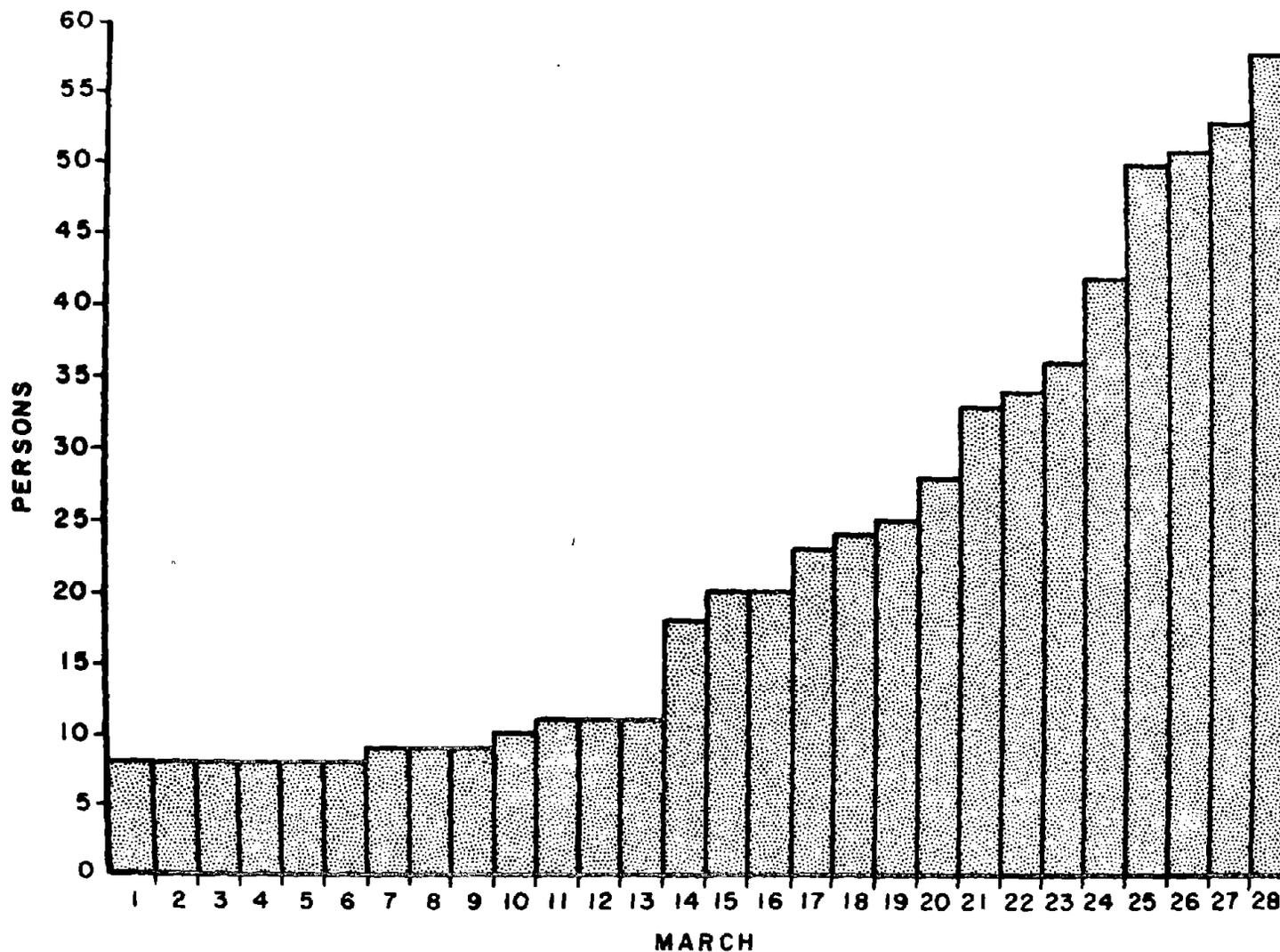
3 Alk phos = Serum Alkaline phosphatase in mU/ml - Normal range = 30-100 mU/ml

4 LDH = Serum Lactate dehydrogenase in mU/ml - Normal range = 100-224 mU/ml

MORRIS FORMAN WASTEWATER TREATMENT PLANT

LOUISVILLE, KENTUCKY

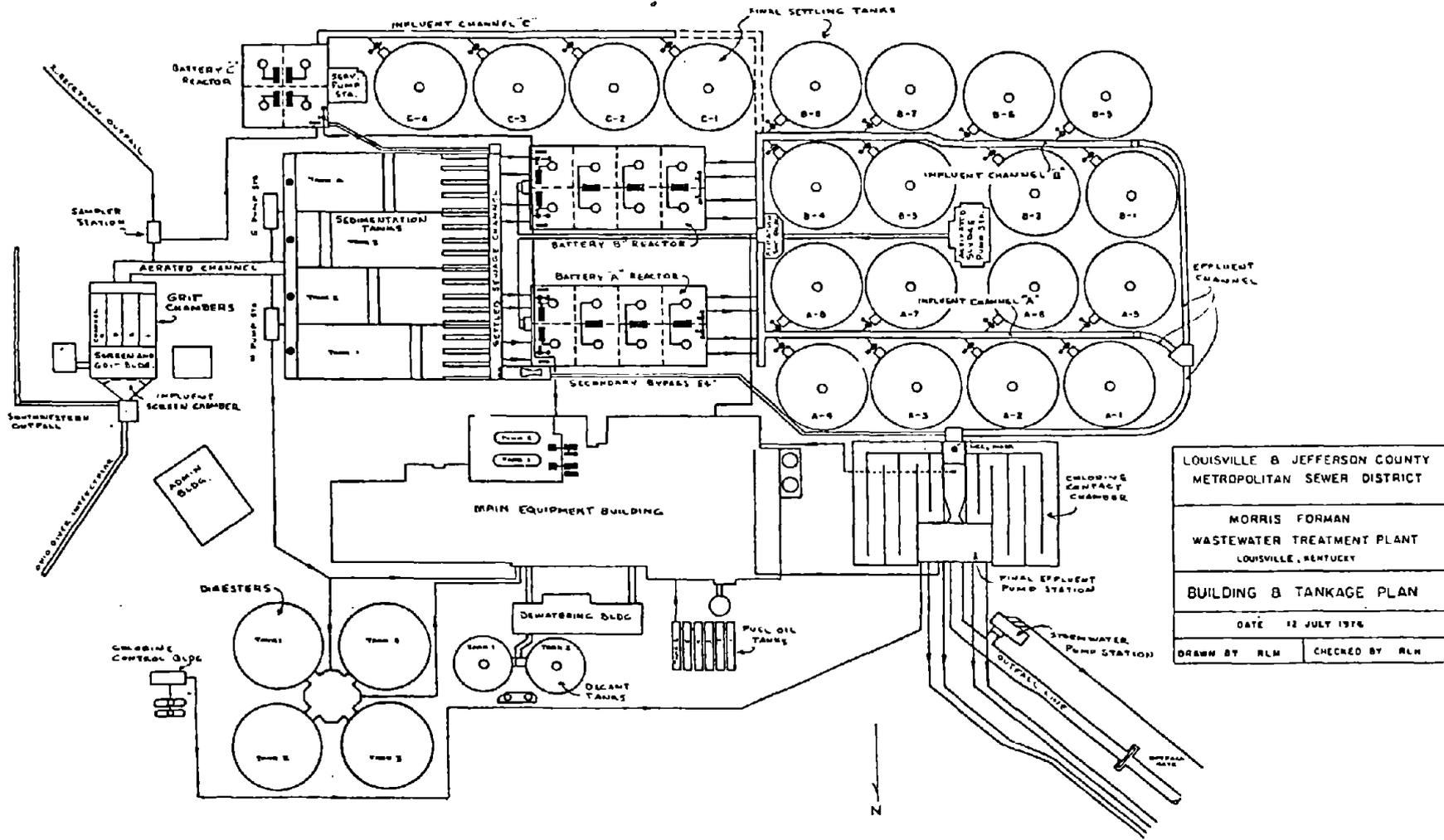
*Fig. 1* EMPLOYEES WHO NOTICED UNUSUAL ODOR AT PLANT, BY DAY, KENTUCKY, MARCH 1-28,\* 1977



\* PLANT CLOSED MARCH 29

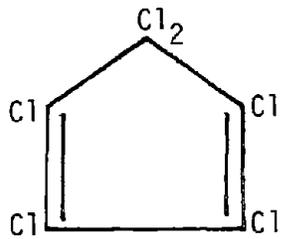
FIGURE 2  
FLOW DIAGRAM

MORRIS FORMAN WASTEWATER TREATMENT PLANT

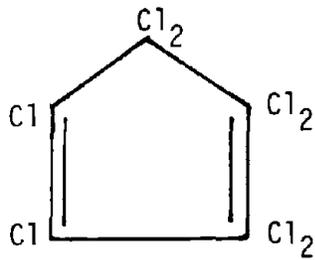


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MORRIS FORMAN WASTEWATER TREATMENT PLANT  
LOUISVILLE, KENTUCKY



Hexachlorocyclopentadiene



Octachlorocyclopentene

Figure 3: Chemical Structures of Hexachlorocyclopentadiene and Octachlorocyclopentene.

APPENDIX I\*

"HEXA INCIDENT"

AGENCY INVOLVED

- 1 = MSD
- 2 = EPA
- 3 = Kentucky Department for Natural Resources & Environmental Protection
- 4 = National Institute for Occupational Safety and Health
- 5 = Kentucky OSH
- 6 = Federal OSHA
- 7 = Louisville & Jefferson County Health Department
- 8 = U. S. Army 43rd Ordnance Detachment
- 9 = Civil Defense
- 10 = Center for Disease Control
- 11 = Louisville Police Department
- 12 = Mayor's Office
- 13 = Federal Disaster Assistance Administration
- 14 = House of Representatives Subcommittee on Investigations & Review - Committee on Public Works and Transportation
- 15 = Louisville & Jefferson County Air Pollution Control District

\* Prepared by the Metropolitan Sewer District, Louisville, Kentucky

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
3/26/77	Unknown material enters MFWTP - Strong odor - Sticky	1	Attempt by 4 employees to clean grit collection equipment
3/27/77	4 employees report symptoms resulting from contact with material - Blue haze over primary tank	1	50 MGD diverted from Diversion Structure to river - Problem found to be associated with this wasteflow
3/28/77	50 MGD diverted to river - Strong odors on plant site - WAVE-TV picks up story	1	EPA (Atlanta) informed, KDNREP informed, Health Department informed - 4 employees report symptoms and are referred to doctor
3/29/77	Attempt to resume normal operation fails - Material identified as Hexa and Octa (possibly lethal) - 15 employees reported sick - Investigation begins	1, 2, 3, 4, 5, 7, 10	100 MGD diverted - Plant abandoned 10:40 AM - EPA and State on scene - Sampling of river, sewers and plant - Velsicol people here to consult - Blood and urine samples to Atlanta
3/30/77	Plant closed - Total of 17 employees reported ill - Sample results back - Hot spots in Broadway sewer and plant - Investigation by MSD & EPA	1, 2, 3, 7, 8	Command headquarters at MSD Main Office - Sampling continues - Effort to discover source continues
3/31/77	Possible danger to residents uncovered - Mayor and City officials notified - Total of 25 employees reported ill	1, 2, 3, 4, 5, 6, 7, 9, 10, 12	212 residents surveyed - No danger - Ambient air sampling of Broadway sewer - Tank truck spilling on I-65 investigated - Gate 88 closed

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
4/1/77	Identification of MSD truck involved in I-65 spill - Results of medical survey completed - Broadway "hot spots" identified	1, 2, 3, 4, 5, 6	Officials and press notified of MSD truck spill - Sampling continues - Louisville Police investigate source of Hexa and Octa - EPA samples reported
4/2/77	Paul Traina in Louisville - Investigation continues - Planning for decontamination begins (R. Jennings in charge) - Heavy rains	1, 2, 11	Sampling continues
4/3/77	Paul Traina in charge of investigation	1, 2, 11	Sampling - Planning to reenter plant - Planning for decontamination - Paul Traina meets with U. S. Attorney
4/4/77	6 million gallons of contaminated material determined to be in plant - 6 tons of Hexa and Octa in plant - MSD Board updated on situation	1, 2, 4, 5, 6, 11	Men reenter plant to check equipment - Planning regarding protective equipment - Teams (EPA, MSD and State) enter suspected sites in Louisville and New Albany - Three options for disposal considered - Sampling
4/5/77	Investigation into source continues - Begin to inquire about funding cleanup - Total of 32 employees under doctor's care	1, 2, 4, 5, 6	Sampling bypasses and river - Portable Gas Chromatograph arrives

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
4/6/77	Decision to isolate Hexa and Octa on plant by pumping to digesters - Traina reports on investigation (phone call) - CDC reports urine and blood samples ok - Mayor Sloane requests federal help - Target date for first week in May to reopen plant	1, 2, 4, 5, 6, 12	Conference call (Dr. Block, Kentucky OSH, Hooker Chemical, Kratt, Dr. DeMunbrun) on clean-up and safety precautions - Sampling continues
4/7/77	Ravan arrives to coordinate Federal effort - Congressional Delegation, Governor and Mayor request funds - FDAA official here	1, 2, 3, 4, 5, 6	Sampling - Planning decontamination effort - Union Local 320 meets with Executive Director
4/8/77	Investigation to U. S. Attorney - Press Conference - Editorials in Courier-Journal and Louisville Times - FBI called in	1, 2, 3, 4, 5, 6	Sampling river, sewers and air at plant
4/9/77	Begin to bleed low toxic water to Ohio River from plant site - Decision to pump sludge to digesters	1, 2, 4, 5	Sampling - Investigation continues - Follow-up on odor problems in homes - EPA involved - Drain secondary clarifiers
4/10/77	EASTER SUNDAY		Sampling

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
4/11/77	Representative Mazzoli at MSD - Indiana House of Representatives urges stop of dumping into Ohio River	1, 2, 4, 5, 6	Training with life support equipment - Sludge pumped to digesters - Planning for plant cleanup - Sample sewers (Broadway), air and water - Continued low toxic water discharge
4/12/77	Attempts to get federal funds for cleanup continue - Legislators contacted, also Mayor Sloane - Aldermen offer \$5,000 reward - Investigators Karseboom and Nolen arrive	1, 2, 4, 5, 6, 13, 14	Sampling - Planning cleanup in sewers - Army asked to scope Broadway sewer - Sludge pumped to digesters - Begin plan cleanup - Continue to drain secondary clarifiers
4/13/77	Representative Mazzoli's office announces congressional appeal for funds - Karseboom and Nolen at MSD	1, 2, 3, 5, 6, 13, 14	Decision on life support equipment for cleanup crews - Sludge pumping continues - Vehicle cleanup - Roadways at site cleaned - Arrangements for Army to scope Broadway sewer - Clean chlorine contact tank
4/14/77	Ravan meets with Works Committee investigators and FDAA representative - NIOSH assumes responsibility for medical follow-up	1, 2, 3, 4, 5, 6	Pump sludge from #4 Sedimentation Tank - Meet with Army to plan for sewer walk - 4 crews to local industries for sampling - Bring work records out of plant
4/15/77	43rd Ordnance Detachment and EPA personnel walk Broadway sewer - Press Conference - Ravan, Bell, Sloane announce federal funding for cleanup - Announce U. S. Attorney "actively pursuing" investigation	1, 2, 3, 4, 5, 6	Sampling of Broadway sewer by Army - MSD accepts responsibility for cleanup - EPA for disposal - Planning for weekend activities

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
4/16/77 & 4/17/77	U. S. Agents find chemical leak in Kentucky Liquid Recycling operation in New Albany	1, 2, 3, 4, 5, 6	Army personnel reenter Broadway sewer - Non-toxic materials at plant bled into Ohio River
4/18/77	General planning for cleanup continues - MSD Board meets - First cameramen on plant site - Also Courier-Journal and Times photographers	1, 2, 3, 4, 5, 6	Pulmonary Capacity tests begin - Screen & Grit cleanup begins - Digesters sampled for second time - Sampling continues
4/19/77	Chem-Trol agents arrive to discuss grit removal - Options for disposal of 6 million gallons of sludge discussed	1, 2, 3, 4, 5, 6	Cleanup on Screen & Grit Building - Results of digester sludge samples arrive - Capping suggested for Broadway sewer
4/20/77	Planning at MSD's Main Office - 24,000 cu. ft. of sludge in Broadway sewer	1, 2, 3, 4, 5, 6	Plant cleanup continues - Plan to flush Broadway sewer considered - two employees picket MSD Main Office - Washdown of Screen & Grit Building begins - Main Equipment Building cleaned - Conditions to enter determined
4/21/77	Ravan testifies in Washington, D. C.	1, 2, 3, 4, 5, 6	Continued cleanup of secondary clarifiers

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
4/22/77	Workers scope diversion chamber	1, 2, 3, 4, 5, 6	Continue cleanup of Primary Sedimentation Tanks - Sampling
4/23/77 & 4/24/77	Flushing of Broadway sewer aborted - bad weather over weekend	1, 2, 3, 4, 5, 6	Plant cleanup continues
4/25/77	Washington Post carries a "Hexa" article	1, 2, 3, 4, 5, 6	Plan to reenter plant - Conference call with Dr. Wisseman (NIOSH) regarding safety at plant - preparations to call workers back - Plan to flush 5' sewer from Broadway to diversion
4/26/77	Attempt to flush sewer by Hydro- Blasting, Inc.	1, 2, 3, 4, 5, 6	Plant cleanup continues - Grit channels de- watered - Dr. DeMunbrun still holding on 37 employees
4/27/77	All workers (except those not medically cleared) back on job - 20,000 ppb in air in sewer from plant to diversion chamber - Times editorial on cleanup	1, 2, 3, 4, 5, 6	Safety precautions explained to plant workers - Planning to vent 11' sewer at head of plant
4/28/77	Ravan and Olson arrive from Atlanta - Problems with pulmonary capacity tests - Plant cleanup continues	1, 2, 3, 4, 5, 6	Plans to clean 11' sewer at head of plant - Plans to clean diversion chamber - Plans to get state pulmonary capacity machine and two tech- nicians - Plans to have industrial nurses on plant site

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
4/29/77	MSD, EPA, etc. meet to develop plans for getting system operative by May 7 - Problems in sewer cleanup discovered - 11' sewer difficult to clean and very contaminated	1, 2, 3, 4, 5, 6	Drain #2 Primary Sedimentation Tank - Clean Aeration Channel - Plan to finish Grit loading Building - Purchase additional respirators and acquire fire hoses for cleanup - Materials shipped to Earthline - Sewer venting begins
4/30/77 & 5/1/77	Plant cleanup continues	1, 2, 3, 4, 5, 6	Plant cleanup continues
5/2/77	EPA reports on initial Zimpro samples - 97% Hexa and Octa removed - MSD Board meets - Karseboom and Nolen at MSD - Administration and Main Equipment Building open	1, 2, 3, 4, 5, 6	Final cleanup on Screen and Grit Building - Air sampling of 11' sewer - 8-10 inches of sludge ten feet wide found - Gravelly tractors modified for sewer cleanup
5/3/77	MSD and Health Department officials meet to develop plan for emergency situations and define roles of respective agencies	1, 2, 3, 4, 5, 6, 7	Inspection of flushing operation at Brewster finds flusher with low suds detergent works - Pulmonary unit returns to plant site - Nurses on job - Gravelly tractors in 11' sewer
5/4/77	Hexa and Octa attack rubber boots and machinery - Work situation in 11' sewer "touchy" - Olson to coordinate federal efforts	1, 2, 3, 4, 5, 6	250 feet of 11' sewer cleaned - Battery lights on Gravellys - Two Bobcats used in sewer clean up

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
5/5/77	Plant cleanup ongoing - Rain delays sewer cleanup - 500 ft. of 11' sewer clean	1, 2, 3, 4, 5, 6	NIOSH M.D. does blood samples on 70 MSD employees
5/6/77	Sewer cleanup delayed - Bobcats breakdown - Gravelys not effective	1, 2, 3, 4, 5, 6	Repair sewer cleaning machinery - Continue plant cleanup
5/7/77 & 5/8/77	Cleanup continues - Plant and sewer	1, 2, 3, 4, 5	#1 and #2 Primary Sedimentation Tanks ready - 4 more Bobcats purchased - Sludge to Rothchild, Wisconsin (Zimpro)
5/9/77	75,000 gallons contaminated material in 11' sewer	1, 2, 3, 4, 5	MSD and EPA to Rothchild, Wisconsin for Zimpro tests - Crews working round-the-clock in sewer
5/10/77	1200 feet of 11' sewer cleaned	1, 2, 3, 4, 5	18 containers (6 cu. yd. each) to Earthline - Zimpro tests begin - Sewer cleanup continues
5/11/77	Plant cleanup ongoing - Could take flow if sewers clean - Toxic levels rise in sewer	1, 2, 3, 4, 5	95-100 decibels in sewer - Earplugs necessary - Hard surface encountered at 1350 feet into 11' sewer - Sewer evacuated 8:30 PM - 1:30 AM 5/12/77

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
5/12/77	1600 feet of 11' sewer cleaned - Prepare to drain ORI - Limitorque gate opened	1, 2, 3, 4, 5	Zimpro samples to Athens - Workers out of sewer while Limitorque gate raised
5/13/77	Hexa and Octa levels reach 11,000 ppb in 11' sewer - Men evacuated 2:30 AM - Inspection by KY-OSH	1, 2, 3, 4, 5	Resample sewer - Plan for more effective venting - Preliminary Zimpro results reported from Rothchild, Wisconsin
5/14/77 & 5/15/77	48" sewer declared free of Hexa and Octa - High toxic levels force men from 11' sewer	1, 2, 3, 4, 5	Cleanup on #3 Sedimentation Tank with "clam" continues - Limitorque gate closed - Blue haze spotted at 2100' into 11' sewer
5/16/77	MSD Board meets - Employees apprehensive about reentering sewer because of "Hexa Haze"	1, 2, 3, 4, 5	Plan to restation venting operation - Division Superintendent walks 11' sewer - Plan to improve supervision of respirators
5/17/77	"Good Air Flow" reported in 11' sewer because of reventing operation - #3 Sedimentation Tank declared operational - Pump sludge to digester #3	1, 2, 3, 4, 5	Vent shifted from 1450' to 2100' - Plans made to lower timbergate in diversion chamber - Operations Department supervising respirator repair, cleanup and cannister change

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
5/18/77	11' sewer cleanup begins again - Six flat tires reported - 33 to date - Men estimated to clean 10 feet per hour - Employee moral improved	1, 2, 3, 4, 5	Timbergate closed - Three containers filled with sludge
5/19/77	NIOSH physician to test employees - Crews reach 1900' into 11' sewer - Work effort good - Venting operation successful	1, 2, 3, 4, 5	Plan final venting operation - Silicone self-seal put in Bobcat tires - Three stop logs removed in Western Interceptor - Plan for cleaning Western Interceptor and Broadway sewer
5/20/77	Men reach 2100' mark in 11' sewer - Blower moved to diversion chamber for last leg of 11' sewer cleanup	1, 2, 3, 4, 5	#1 and #3 digesters recirculated - MSD/NIOSH meeting at plant - Eight containers of sludge removed from 11' sewer and Primary Influent Chamber in 24 hours - Limitorque gate closed
5/21/77 & 5/22/77	Heavy flow in 11' sewer - Timbergate leaking - Air sampling delayed because of water in sewer	1, 2, 3, 4, 5	Timbergate closed - Water in sewer shorts out Bobcats - Sandbagging behind timbergate to stop flow - Mickey Kalbhin injured
5/23/77	Men evacuate sewer because of Hydrogen Sulfide - Respirators useless with H <sub>2</sub> S	1, 2, 3, 4, 5	Planning to get heavy flow out of 11' sewer - Venting continues to control "Hexa Haze" - Digester decanting responsible for H <sub>2</sub> S in 11' sewer - Decanting ceased

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
5/24/77	H <sub>2</sub> S readings of 70 ppm in sewer - Emergency procedures reviewed by NIOSH officials - Plans laid for revamping life support equipment	1, 2, 3, 4, 5	NIOSH conference call - Recommendations include self-contained air for workers in 11' sewer - Timbergate raised and sandbags removed
5/25/77	Congressional committee investigators (Karseboom & Nolen) at MSD - 54" sewer found to be clean	1, 2, 3, 4, 5	Neoprene seal on timbergate eliminates flooding problem in sewer - Planning for releasing medical information to men - Planning for clean-up of Broadway sewer
5/26/77	New life support equipment arrives - Men back in 11' sewer at 6:00 PM - Three men refuse to reenter sewer	1, 2, 3, 4, 5	Training with new life support equipment completed - Air containers mounted on Bobcats - "60 Minutes" filming at SAS Earthline site - EPA announces depth sampling of Ohio River
5/27/77	Cleanup of 11' sewer continues - Governor of Illinois announces 45-day moratorium on Earthline site	1, 2, 3, 4, 5	Plan to profile ORI - Tests show 200,000 ppb Hexa and 1,000,000 Octa at 50' in 8' ORI
5/28/77 & 5/29/77	Cleanup of 11' sewer continues - CBS story on Earthline aired Saturday, May 28 - 11' sewer cleaned by 7:30 Sunday	1, 2, 3, 4, 5	Timbergate opened at midnight Sunday to drain 8' ORI

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
5/30/77	MEMORIAL DAY	1, 2, 3, 4, 5	9 sludge samples from ORI taken and sent to Athens, Georgia
5/31/77	Possibility of dump in 8' ORI considered - Sample results from Athens delayed	1, 2, 3, 4, 5	Begin to design Bobcat blades for cleanup of 8' ORI - Cleanup effort on 8' ORI begun with Gravelly Tractor
6/1/77	Rubbertown flow taken into plant at 1:30 PM - First flow in plant since March 29 - Sample results arrive - 5,000' of contaminated sludge in 8' ORI - Heaviest concentrations downstream - Charles Horn arrested by FBI	1, 2, 3, 4, 5	125' of 8' ORI cleaned - Measure flow on 8' ORI to determine variance over 24-hr. period - Begin to plan cleanup of Broadway sewer
6/2/77	Southwestern Interceptor flow in plant - Distler arrested - CBS TV on plant site - Report on Cronkite show	1, 2, 3, 4, 5	Larger entrance cut at Diversion Chamber - Sample results indicate 1500' of 8' ORI needs cleaning - Bobcats and men back in 8' ORI at 4:30 PM as major cleanup begins
6/3/77	Cleanup of 8' ORI complete at 7:00 AM	1, 2, 3, 4, 5	Plan for opening (85%) of plant by Sunday midnight (June 5) - Discuss future role of NIOSH in cleanup operation - Plan cleanup of Broadway sewer

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
6/4/77	Begin taking ORI, Southern & Southwestern flows, 70% by Saturday, June 4	1, 2, 3, 4, 5	Final cleanup around Screen & Grit Building - NIOSH sampling continues
6/5/77	System 85% operational - Heavy rains	1, 2, 3, 4, 5	John Kominsky leaves
6/6/77	MSD, EPA, Air Pollution Control Board meets concerning use of Zimpro processing of digester sludge	1, 2, 3, 5	HCB's in Zimpro emissions - Planning for Broadway cleanup
6/7/77	400' of 5' Western Interceptor cleaned by Hydro-Blasting, Inc.	1, 2, 3, 5	Hauling grit to Mobile Waste landfill on Grade Lane - EPA requests grit samples report - 27" gate at Broadway broken - Plan cleanup of 54" sewer at plant - Discover Gate #1 mistakenly closed
6/8/77	Three truckloads of material to Earthline - NIOSH reports some evidence of Hexa and Octa in air at Screen & Grit Building	1, 2, 3, 5	Plan for core sampling at Mobile Waste landfill - EPA will consult with Kentucky Solid Waste

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
6/9/77	Article in Courier on cleanup crews - 138,142 Hexa and 250,586 Octa readings in Western Interceptor - Conference call with NIOSH about life support equipment for Broadway sewer cleanup	1, 2, 3, 5	27" gate removed from Broadway sewer - Timber replacement 90% effective - Plan scope of Broadway sewer sampling and profile
6/10/77	Rains bring residual Hexa & Octa into plant - EPA, KDNREP approve decision to divert so front end of MFWTP can be decontaminated	1, 2, 3, 5	Hexa 8,000 ppb, Octa 10,000 ppb found in grit - EPA sample results indicate heavy contamination in Western Interceptor - Plan cleanup operation at plant, 11' sewer and diversion
6/11/77 & 6/12/77	Flow diverted to Ohio River - MFWTP shut down	1, 2, 3, 5	Cleanup operation continues
6/13/77	Plant cleanup continues - Rain delays efforts	1, 2, 3, 5	Diver sent into diversion chamber to close gate - Cleanup on 11' sewer begins
6/14/77	Bobcat catches on fire in 11' sewer - One man suffers burns - A second injury forces decision to temporarily suspend sewer cleanup and rest the men	1, 2, 3, 5	Broadway sewer walk confirms earlier Army-EPA results

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
6/15/77	Sewer cleanup resumes - Arrangements for core samples at Mobile Waste Landfill - Plant cleanup continues	1, 2, 3, 5	Second contractor brought in to help with plant cleanup - Work in 11' sewer continues
6/16/77	11' sewer cleaned by 11:00 AM - Pumps in diversion chamber fail	1, 2, 3, 5	NIOSH safety recommendations arrive - Contingency plan developed regarding possible recontamination of plant - Hexa 44,000,000 ppb found at 28th and Broadway
6/17/77	Decontamination effort in diversion chamber complete - Begin taking flow into plant	1, 2, 3, 5	5 men overcome by carbon monoxide fumes in diversion chamber - 2 sent to General Hospital 3 sent to SS Mary & Elizabeth Hospital - Gasoline pumps shut off - Men reenter chamber and finish work
6/18/77	Continue bringing flow into plant at 70% capacity by Saturday evening	1, 2, 3, 5	Continued to divert Southern Outfall to Ohio River because of possible contamination
6/19/77	Heavy rains	1, 2, 3, 5	Monitor storm flow into MFWTP
6/20/77	MSD Board meets - Cleanup of secondary system nears completion	1, 2, 3, 5	Sampling on Southern Outfall begins

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
6/21/77	Planning cleanup on Western Interceptor - Three options considered	1, 2, 3, 5	Design for "Cub Cadet" blades complete - A & C Unox Batteries reported clean - B Battery needs cleaning
6/22/77	Plans for ventilation of Western Interceptor complete - Health Dept. report on Hexa incident released	1, 2, 3, 5	Need for ventilation profile determined - Hearing protection for workers in Western Interceptor required by KY-OSH
6/23/77	U. S. Attorney - MSD meetings held at MSD Building & MFWTP - MSD workers named "Citizens of the Day" by WLOU	1, 2, 3, 5	MSD-EPA officials meet on disposal costs - EPA-Versar officials meet on sludge disposal from digesters
6/24/77	Core samples taken at Grade Lane Landfill show low levels of Hexa and Octa - Air sampling results should clear MFWTP as no mask area	1, 2	Plans for Zimpro run completed
6/25/77 & 6/26/77	Influent/effluent samples taken at plant and sent to Athens	1, 2	Zimpro unit brought on line for 6/28 test
6/27/77	Zimpro test successful - Versar sampling at 21 locations	1, 2, 15	Complete plans for incineration phase of sludge disposal test - EPA, Air Pollution and MSD officials meet to review Versar sampling tests

APPENDIX I  
(continued)

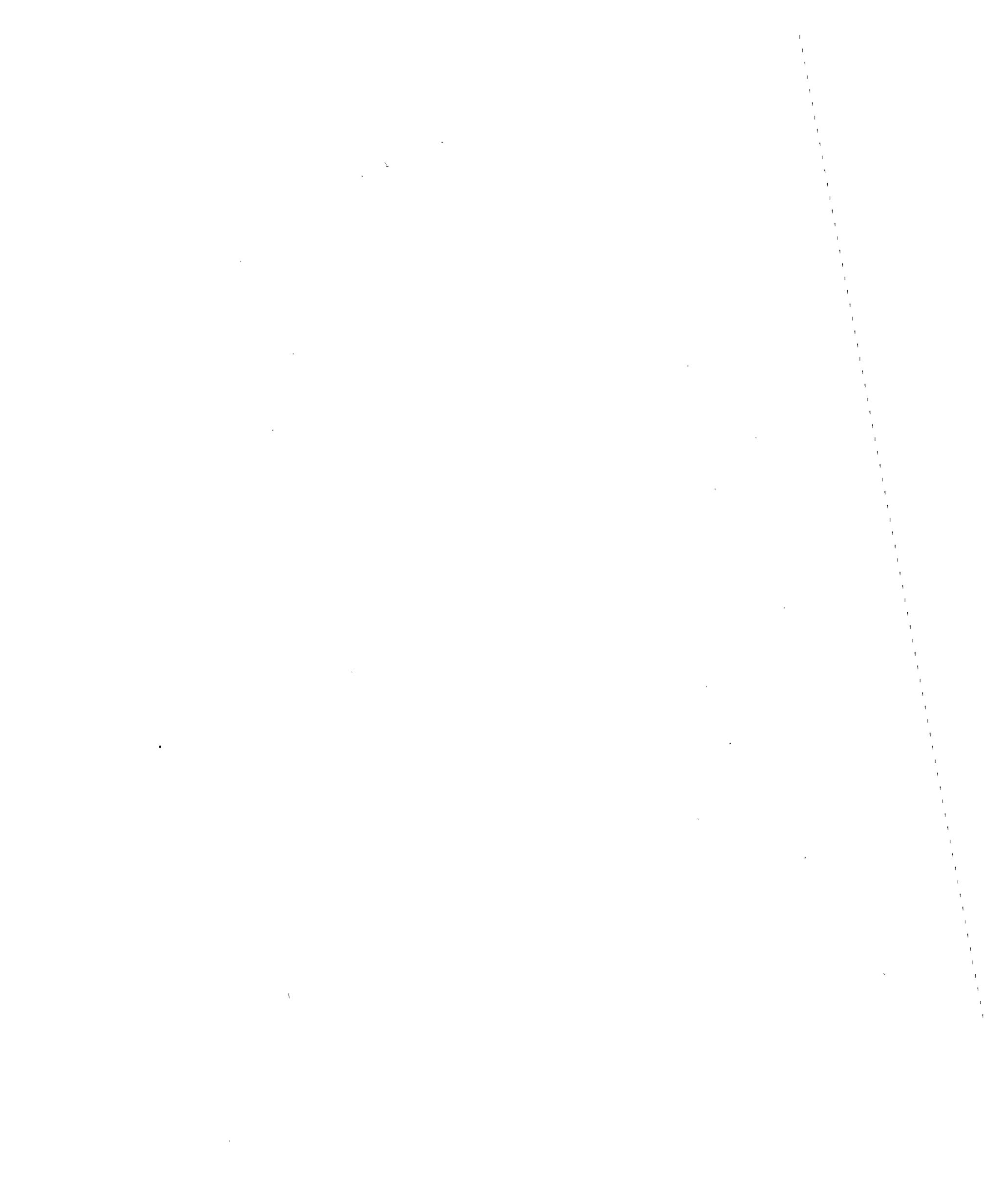
DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
6/28/77	Phase II of sludge disposal test extended to modify analytic techniques and monitoring requirements	1, 2, 15	Planning for Western Interceptor cleanup continues
6/29/77	MSD Maintenance employees request hazardous duty pay for sewer decontamination work - Phase II of sludge disposal successful	1, 2, 15	Continue air-sludge sampling
6/30/77	Southern Outfall brought into plant	1, 2, 15	EPA, Air Pollution and MSD officials meet to review Versar sampling results and plan for on-going monitoring of sludge disposal process
7/1/77	Decision made to clean Western by machine	1, 2	MSD/EPA officials review plans to use Hydro-Blasting machine in 42" sewer
7/2/77, 7/3/77 & 7/4/77	JULY FOURTH WEEKEND		JULY FOURTH WEEKEND
7/5/77	MSD Board meets	1	MSD/Hydro-Blasting, Inc. meeting to discuss contract for cleaning Western Interceptor

APPENDIX I  
(continued)  
AGENCY  
INVOLVED

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
7/6/77	Plans to scope 42" sewer delayed until 7/7/77	1	Gate 88 opened for 12 hour period to release backwater in 42" sewer
7/7/77	Air Pollution & Health Department meet regarding sewer cleanup - Sludge deposits from 1-3" reported in Northwestern Interceptor - Samples show 10,812,000 ppb Hexa and 6,342,000 Octa in sludge at 1st manhole north of Broadway	1, 2, 7, 15	Versar at MFWTP to update monitoring activity
7/8/77	MSD and KDNREP meet regarding Hexa and Octa levels in material at Grade Lane Landfill	1, 2, 3	ORSANCO requests KDNREP action regarding MFWTP effluent
7/9/77 & 7/10/77	Operators at MFWTP begin "sick-out" at end of 2nd shift Sunday	1	Supervisory staff at MFWTP maintain plant operation during "sick-out"
7/11/77	95% of Operators at plant absent "due to illness" - Courier-Journal reports "sick-out" as part of a job action - Air Pollution and MSD officials meet on safeguards during sewer cleanup	1, 15	MSD and Local 320 officials meet to resolve work situation at plant - Local 320 states job action has no Union sanction

APPENDIX I  
(continued)  
AGENCY  
INVOLVED

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
7/12/77	Operators back on job	1	U. S. Government Accounting Office and MSD officials meet



APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
7/26/77		1	Continuing processing contaminated digester sludge round the clock - air, sludge, grit, personnel monitoring - Continuing chloronation - Preparing proposal for decontaminating Broadway Sewer - All flow temporarily diverted from plant to check sewers and Diversion Structure for 48" plug (divert from 8:00 AM to 2:00 PM) - Found plug in Diversion Structure - Hydro-blast work planned for Thursday, July 28 AM
7/27/77		1	Continuing processing contaminated digester sludge round the clock - air, sludge, grit, personnel monitoring - Continuing chloronation - Preparing proposal for decontaminating Broadway Sewer - Picketing at MSD Building by 40+ Laborers' Local 576 Maintenance Division employees (after normal work hours - 4:00 - 5:00 PM) - Telegram to J. E. Stewart, Business Manager Local 576, informing him that negotiations will be suspended if picketing activities not terminated
7/28/77		1	Continuing processing contaminated digester sludge round the clock - air, sludge, grit, personnel monitoring - Continuing chloronation - Preparing proposal for decontaminating Broadway Sewer - No more picketing by Local 576 - Hydro-blast cleaned 439' of 42" Western Interceptor from Larkwood sewer to 1st manhole south of Larkwood Sewer
7/29/77		1	Continuing processing contaminated digester sludge round the clock - air, sludge, grit, personnel monitoring - Continuing chloronation - Preparing proposal for decontaminating Broadway Sewer - Rain, no work in Western Interceptor

APPENDIX I  
(continued)

DATE	SITUATION	AGENCY INVOLVED	ACTION TAKEN
7/22/77		1, 15	Continuing processing contaminated digester sludge round the clock - air, sludge, grit, personnel monitoring - Started chlorinating effluent (2½ tons/day) - Completed installation of curtains in 42" Western Outfall at Larkwood and in Southern Outfall at Diversion - Sealed all manholes along Western Outfall - All in accordance with APCD requirements - Plan for Hydro-blast to begin cleaning 42" Western Interceptor Monday, July 25, 1977 - Preparing proposal for decontaminating Broadway Sewer
7/23/77		1	Continuing processing contaminated digester sludge round the clock - air, sludge, grit, personnel monitoring - Continuing chloronation
7/24/77		1	Continuing processing contaminated digester sludge round the clock - air, sludge, grit, personnel monitoring - Continuing chloronation - Preparing proposal for decontaminating Broadway Sewer - Heavy rains P.M.
7/25/77		1	Continuing processing contaminated digester sludge round the clock - air, sludge, grit, personnel monitoring - Continuing chloronation - Preparing proposal for decontaminating Broadway Sewer - Heavy rains early A.M. - Hydro blast work aborted because of rains and proposed rains - Also 48" plug blown by surcharge on 48" from rains and washed into sewer or Ohio River?

## APPENDIX II

### COLLECTION AND ANALYTICAL PROCEDURES FOR HEXACHLOROCYCLOPENTADIENE AND OCTACHLOROCYCLOPENTENE

Sample Collection and Shipment: The sampling tubes were constructed of glass approximately 7-cm long containing 2 sections of 20/40 mesh commercial Chromosorb 102 separated by a 2-mm portion of urethane foam. The absorbing section contained approximately 100 mg of commercial Chromosorb 102 while the backup section (used as the blank) contained approximately 50 mg. To alleviate the interferences associated with commercial Chromosorb 102 it was pre-extracted. The Chromosorb was Soxhlet extracted with 1:1 acetone-methanol solution for 8-hours and dried in a vacuum oven at approximately 80° C. The extraction removed most interferences especially those interfering with HCCPD and OCCP.

After collection the samples were refrigerated until being transported to NIOSH's Cincinnati laboratory for analysis. Upon arrival, the samples were analyzed the same day or stored under refrigeration until analysis.

Analysis: Each section of the tube was desorbed with 500 µl of carbon disulfide aided by sonification for one hour. An aliquot of approximately 5 µl was injected into a gas chromatograph (GC) equipped with a flame ionization detector (FID) for analysis.

Due to the large number of samples, two gas chromatographs were utilized. Listed below are the following GC conditions for both instruments.

<u>Instrument</u>	<u>Hewlett-Packard 5710A</u>	<u>Perkin Elmer 900</u>
Detector	FID	FID
Column	10' glass 10% OV-101 on 60/80 Supelcoport	10' glass 6% SP2100 on 60/80 Supelcoport
Initial Temp.	180° C	130° C
Initial Time	--	4 min
Program	Isothermal	4° C/min
Final Temp.	180° C	155° C
Final Time	--	16 min
Injector Temp.	on-column injection	250° C
Detector Temp.	250° C	250° C
Flowrate	17 ml/min (N <sub>2</sub> )	15 ml/min
RRT (HCCPD)	6.5 min	18.5 min
RRT (OCCP)	7.5 min	17.5 min

APPENDIX II  
(continued)

Peak area for each compound was calculated by data processor and compared to the peak area of standards in the same range and calculated as total  $\mu\text{g}$ . Total  $\mu\text{g}$  was divided by the desorption efficiency to give corrected  $\mu\text{g}/\text{sample}$ .

The  $\text{mg}/\text{M}^3$  was calculated by dividing the  $\mu\text{g}/\text{sample}$  by the air sampling volume in liters. The ppb was calculated using the following equation:

$$\text{ppb} = \text{mg}/\text{M}^3 \times \frac{24.45}{\text{MW}} \times 1000$$

MW for HCCPD is 273 and for OCCP is 344.

Desorption efficiencies of HCCPD and OCCP were determined by spiking 100 mg of pre-extracted Chromosorb 102 with both HCCPD and OCCP at a concentration of  $\frac{1}{2}$ , 1, and 2 times the TLV (10 ppb) for HCCPD assuming a 10 liter air sample. After allowing time for complete absorption, the samples were desorbed with 500  $\mu\text{l}$  of carbon disulfide, sonified for 1 hour, and analyzed in the same manner as the samples. HCCPD yielded a desorption efficiency of 68% while OCCP yielded 100%.

\* The sampling and analytical procedures were developed by the Measurement Support Branch, NIOSH, Cincinnati, Ohio. The sampling and analytical procedures were presented by C. Neumiester and R. Kurimo at the 1978 American Industrial Hygiene Conference in Los Angeles, California.

APPENDIX III

NIOSH  
Hazard Evaluation and Technical  
Assistance Report TA 77-39

**TO :** Director, **DATE:** April 5, 1978  
Division of Surveillance, Hazard Evaluations, and Field Studies  
Thru: Acting Chief, Hazard Evaluations & Technical Assistance Branch, DSHEFS  
Thru: Chief, Industrial Hygiene Section  
Thru: Chief, Medical Section

**FROM :** Project Officer, IHS, HETAB  
Medical Officer, MS, HETAB  
Chemist, PES, CTRB

**SUBJECT:** SHEFS 1 REPORT: HETAB Project TA 78-27  
Louisville and Jefferson County  
Metropolitan Sewer District  
Louisville, Kentucky

**I. INTRODUCTION/BACKGROUND STATEMENT OF REQUEST**

The effort to clean the parts of the Metropolitan Sewer District (MSD) system contaminated with hexachlorocyclopentadiene and octachlorocyclopentene is substantially complete. The Morris Forman Wastewater Treatment Plant is treating approximately 85 million gallons of wastewater per day (approximately 85 percent of the average normal daily flow). Decontamination of the Western Outfall and Western Interceptor Sewers must be accomplished before MSD's operations can be completely back to normal. This effort will consist of decontaminating (1) approximately 9,700 linear feet of the 9'6" and 10'6" Western Outfall, and (2) approximately 1,790 linear feet of 42" and 4,990 linear feet of 60" sewers, called the Western Interceptor. NIOSH received a formal request from the Kentucky Department of Labor, Occupational Safety and Health Program, Division of Training and Education, to attend a meeting to discuss work procedures and practices that would facilitate the safe and healthful decontamination of the Western Outfall and Western Interceptor Sewers.

**II. ACTIONS TAKEN TO DATE**

On March 10, NIOSH was represented by Mr. Charles E. Neumeister, Dr. Eugene R. Kennedy, Dr. Mitchell Singal, and Mr. John R. Kominsky at a Kentucky Department of Labor/MSD meeting held in Louisville, Kentucky regarding safety and health measures that would be used to decontaminate the Western Outfall and Western Interceptor Sewers.

APPENDIX III  
(continued)

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There is an estimated 250 to 300 cubic yards of sewage which has been contaminated with hexachlorocyclopentadiene and octachlorocyclopentene in these sewers. It has not been definitely decided on how the decontamination might be accomplished, although most likely the Western Interceptor Sewers will be decontaminated using a mechanical device to drag the material within the sewer to an area for removal by surface equipment. The material will be packaged in disposable containers for ultimate disposal at a chemical burial site in Wilsonville, Illinois. Due to the unknown structural integrity such a device cannot be used in the Western Outfall Sewer. Most likely the contaminated material will be manually removed by the workers. Decontamination of the Western Interceptor Sewer is slated to begin in mid-April and is expected to take approximately 6 weeks involving two 12-hour shifts per day. Decontamination of the Western Outfall Sewer will begin immediately thereafter; the time required has not been estimated.

The following safety and health proposals were discussed at the meeting:

1. Respiratory Protection

- a. Due to the unknown chemical composition of the sewer's atmosphere and its potential to change rapidly and without notice, particularly in the Western Outfall which receives both commercial and industrial sewage, the underground personnel will be required to use open-circuit air-line supplied respirators. Each person also will be equipped with a 15-minute egress bottle for emergency evacuation.
- b. Surface personnel will be required to wear full- or half-face chemical cartridge respirators, the type depending on the concentrations of hexachlorocyclopentadiene and octachlorocyclopentene measured. A subjective index will be whether or not eye irritation is experienced.
- c. A respiratory protection program meeting the requirements of 29 CFR 1910.134 will be established and enforced by MSD management.
- d. Employees will be properly trained in the use, care, and limitations of the respirator assigned to them. The workers will be trained in qualitative fit testing procedures for chemical cartridge respirators. The qualitative test will be conducted by each worker before entry into a contaminated atmosphere.

APPENDIX III  
(continued)

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2. Personal Protective Clothing

- a. All personnel will wear a 2-piece plastic coated disposable suite, vinyl gloves, and rubber boots. Persons working underground will be required to tape the suit around the neck and wrist areas, and wear hip boots instead of knee-high boots.

3. Equipment Issuance and Maintenance

- a. A central facility will be established for the issuance and maintenance of the protective equipment. Daily or more frequently, if necessary, the equipment will be decontaminated and disinfected, inspected and repaired when needed.

4. Personal Hygiene

- a. A facility will be established for wash-up, eating, etc. Arrangements are being made to use a YMCA facility located in the immediate work area. Each person will be provided with clean work garments (shirt and pants) daily.

5. Rescue Training

- a. Every person directly involved will be adequately trained in appropriate First Aid procedures.
- b. Each underground worker will be provided with arm wristlets for rapid removal from the sewer.
- c. Arrangements are being made with the area Fire Department to provide paramedical personnel and ambulatory vehicles, if necessary.

6. General

- a. The Kentucky Department of Labor, Division of Compliance will require MSD to comply with their confined space standard (803 KAR 2:015, Sections 3-6).

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(continued)

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Additional NIOSH recommendations are as follows:

A. Personal Protective Equipment

1. Respiratory Protection

- a. Respiratory protective equipment should be issued with caution. There might be individuals in the group for whom wearing a respirator carries certain specific dangers, i.e. highly increased resistance to airflow in a person with compromised pulmonary function may be associated with acute respiratory insufficiency. The Kentucky Department of Labor has made extensive recommendations regarding initial screening of workers for the ability to wear a respirator. We have no additional recommendations on this subject.
- b. The NIOSH publication titled "A Guide to Industrial Respiratory Protection", will serve a reference source for establishing and maintaining a respiratory protection program which meets the requirements of 29 CFR 1910.134.
- c. Respirator Fitting: In addition to qualitative fit testing, it is recommended that quantitative testing also be conducted. The quantitative test is recommended when facepiece leakage must be minimized for work in highly toxic atmospheres or those immediately dangerous to life or health. Our experience in the Ohio River Interceptor showed us that such concentrations periodically existed. Thus, it is reasonable to expect that equally high concentrations may exist during decontamination of the Western Outfall and Western Interceptor sewers. Respirator fit testing procedures are outlined and discussed in Chapter 8 of the NIOSH publication "A Guide to Industrial Respiratory Protection". The only portable fit testing unit that we know belongs to Armco Steel Corporation, Middletown, Ohio

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(continued)

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- d. Frequent inspection of breathing air lines, protective suits, boots, etc. should be conducted. A laboratory study might be warranted to determine the permeation characteristics of hexachlorocyclopentadiene and octachlorocyclopentene through the above materials. Reference 15 provides instructions for permeation cell construction. The breathing air lines should not be allowed to lay in the contaminated sewage.
- e. The quality of the breathing air supplied to the air line respirators must meet the requirements for air purity set forth in ANSI Z9.2-1960 and comply with Federal OSHA Regulations (1910.94 (a)(6) and .134 (d)).
- f. Communication between surface and underground personnel should be achieved using a radio system instead of the proposed freon horns. (The horns could still be carried as a back-up communications system.)
- g. In areas and at operation sites where the use of respiratory protection is required, the employees should wear the designated type of respirator and observe the practices of the respiratory protection program. The necessity of cleanliness and maintenance of respirators should be emphasized. Practices which lead to the contamination of the interior of the facepiece should be prohibited.

## 2. Protective Clothing

- a. The proper use of protective clothing requires that all openings be closed and that garments fit snugly about the neck, wrist, and ankles whenever the wearer is in an exposed area, particularly underground.
- b. Clean protective clothing should be put on before each work shift. At the end of the shift, the employee should remove soiled clothing, place it in a covered container provided, and shower before putting on his street clothes. The shower should include a good lathering with soap. The clothing should be held in these containers until removed for decontamination or disposal. These procedures should also apply during a shift, if the work clothing becomes grossly contaminated with hexachlorocyclopentadiene.

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(continued)

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- c. Gloves, boots, and other personal protective devices must be maintained in good hygienic and uncontaminated condition. They should be cleaned or replaced frequently on a regular schedule.

3. Emergency Washing Facility

- a. The availability of an unrestricted supply of water should be provided and be quickly accessible. The water may be provided by a free-running hose, at low pressure, or by some type of emergency shower.

4. Resting Area

- a. Workers may reduce the potential exposures significantly by retiring to clean areas when their presence at the operation point is not necessary. A clean area may simply be a room or a space where sustained environmental levels are such that it can be considered as being without occupational exposure to hexachlorocyclopentadiene. A clean area can be deliberately established by means of ventilation which provides either filtered air or air from an uncontaminated source in a manner and amount which maintains the environmental level of hexachlorocyclopentadiene at a non-exposure level.
- b. The resting area should be shaded from the sun and ample cold, potable water should be available.

5. Medical Surveillance

- a. In order to minimize potential hepatic and renal effects to hexachlorocyclopentadiene, the initial medical screening should establish the absence of known liver disease. In addition to the general medical history (see 1. a.), questions concerning alcohol consumption and use of medications should be asked. Consumers of large amounts of alcohol and users of hepatotoxic and renal toxic drugs should be excluded. Liver function tests (serum bilirubin and liver enzymes), a routine urinalysis, and serum creatinine and/or urea nitrogen (BUN) should be done, and anyone with results suggestive of liver or kidney dysfunction should be excluded.
- b. A system for reporting symptoms of exposure should be instituted, and a log of such reports should be maintained. Such a log will enable MSD and its medical consultant to determine any adverse trends in exposure incidents.

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(continued)

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- c. Periodic monitoring of liver function should be done; serum bilirubin and liver enzyme determinations every 2-3 weeks should be adequate. Any worker showing evidence of impaired liver function should be removed from further exposure.
- d. Periodic monitoring of renal function in exposed workers did not suggest any problem in 1977 and is therefore not included in these recommendations. However, since it does not require any blood in addition to that obtained for the liver function tests, and since a urinalysis is inexpensive and involves no substantial inconvenience to workers, MSD may wish to include renal function monitoring along with liver function monitoring.
- e. A test for blood and urine levels of hexachlorocyclopentadiene is reportedly available. However, since the levels of hexachlorocyclopentadiene (or its metabolites) in body fluids that constitute a "biologic effect" or "toxic" level is unknown, we do not think such a test would be useful at this time for medical monitoring. However, should someone wish to evaluate the utility of the test in an occupational exposure setting, this project would provide a good opportunity.

6. Environmental Surveillance

- a. MSD technicians have been trained by NIOSH in the appropriate sampling and analytical methodologies for hexachlorocyclopentadiene and octachlorocyclopentene. It is recommended that the environmental surveillance program used during the decontamination of the Ohio River Interceptor be adopted for the Western Outfall and Western Interceptor sewers. However, it should also include monitoring of several surface workers who are directly involved.
- b. Unlike the Western Interceptor sewers, the Western Outfall is directly connected to commercial and industrial premises. Thus, in addition to hexachlorocyclopentadiene and octachlorocyclopentene, the workers also will be potentially exposed to a variety of other organic contaminants. Based on the type of industry connected to the sewer, MSD speculates that the chemical wastes will consist primarily of organic solvents such as toluene, xylene, styrene, etc.

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(continued)

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Therefore, it is recommended that the underground personnel wear a second sampling apparatus using activated charcoal as the collection medium to characterize more fully the work environment. The first samples should be submitted for gas chromatograph-mass spectrophotometer analysis. These results should be reviewed by a professional industrial hygienist for subsequent sampling and analysis recommendations.

- c. The percent oxygen should be frequently determined. Less frequent determinations using a direct reading instrument such as detector tubes should be made for carbon dioxide, methane, hydrogen sulfide, and ammonia.
- d. The air sampling data obtained each day should be reviewed by a professional industrial hygienist. The environmental exposure data must be integrated with the physical status data in a manner that considers length of exposure, time-weighted average exposure and peak exposure concentrations. The workers' exposure to multiple chemical agents must also be considered.
- e. Records of environmental exposures to hexachlorocyclopentadiene and octachlorocyclopentene should be maintained. Records should indicate the details of (1) type of personal protective equipment, if any, in use at the time of sampling, and (2) methods of sampling and analysis used.

IV. FURTHER ACTIONS

At this time NIOSH field participation has not been requested and does not appear to be necessary. During the meeting MSD and Kentucky Department of Labor were informed that NIOSH personnel will be available for industrial hygiene and medical consultations.

*John R. Kominsky*

John R. Kominsky, M.S.

*Mitchell Singal*

Mitchell Singal, M.D.

*Eugene R. Kennedy* /JK

Eugene R. Kennedy, Ph. D.

APPENDIX IV

# MEMORANDUM

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE  
PUBLIC HEALTH SERVICE  
CENTER FOR DISEASE CONTROL  
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

TO : Chemist  
(Fred Phipps)  
Clinical and Biochemical Support Section  
Through: Chief, BSB *MPW*

DATE: February 14, 1978

FROM : Research Veterinary Medical Officer

SUBJECT: Pathology report on rats exposed to hexachlorocyclopentadiene (HCPD)

Female rats were gavaged with varying doses of hexachloropentadiene. All animals were killed 24 hours posttreatment. At autopsy the lungs, liver, spleen, kidneys, adrenals, heart, stomach and intestine (small and large) were saved for histopathology evaluation.

1.1. Control female rats

Path. Access #77-0631 and 77-636

Gross Pathology: No gross pathology was seen.

Histopathology:

Lungs: The morphologic changes were similar to those seen in "chronic pneumonia of murines."

The other organs examined were unremarkable.

1.2. Female rats gavaged with 300 mg/kg of HCPD.

Path. Access #77-632 and 77-633

Gross Pathology: Brown discoloration around the nostrils and the anus of both rats was seen. The urinary bladder of both rats contained brown fluid.

Histopathology:

Lungs: Atelectasis with moderate thickening of the alveolar walls was seen in both rats. The alveolar walls contained moderate numbers of macrophages and neutrophils. Some bronchial lumina contained denuded epithelium. No edema was present in the lungs. Chronic pneumonic changes of rats were present.

Stomach: The entire squamous epithelium showed coagulative necrosis. The submucosa of the nonglandular part of the stomach showed mild neutrophilic infiltration. The (submucosa, submuscularis and muscularis) supporting structures of the nonglandular stomach showed moderate edema. The epithelium or the supporting structures of the glandular part of the stomach did not show any morphologic changes relatable to treatment.

The other organs examined were unremarkable.

APPENDIX IV  
(continued)

Chemist

2

2.1. Female rat gavaged with 150 mg/kg of HCPD.

Path. Accss #77-634

Gross Pathology: The rat was found dead and in a state of marked decomposition. Brown discoloration around the nostrils. Congestion of all organs was seen.

Histopathology:

Lungs: Autolytic changes.

Stomach: Autolytic changes coupled with the changes similar to those seen in 1.2, but the changes are of very mild in degree.

All the other organs examined showed autolytic changes.

3.1. Female rats gavaged with 50 mg/kg of HCPD.

Path. Accss #77-635 and 77-637

Gross Pathology: Thickened stomach wall was seen in both rats.

Histopathology:

Lungs: The changes are similar to those seen in 1.1.

Stomach: The superficial layers of the squamous epithelium of the nonglandular part of the stomach showed coagulative necrosis while the basal layer was not affected in both rats. In 77-637 there were two microscopic ulcers (focal) in the non-glandular part which extend the full thickness of the epithelium. The supporting structures in both rats showed mild edema with neutrophils. The glandular part of the stomach was unremarkable.

The other organs examined were unremarkable.

4.1. Female rat gavaged with 100 mg/kg of HCPD.

Path. Accss # 77-638

Gross Pathology: Thickened stomach wall was seen.

Histopathology:

Lungs: The alveolar walls showed mild thickening with macrophages and neutrophils.

Stomach: Marked neutrophile infiltration and edema in the supporting structures of the nonglandular part of the stomach coupled with coagulative necrosis of the squamous epithelium. The exudative changes extend to the peritoneum causing acute peritonitis. The glandular part of the stomach was unremarkable.

The other organs examined were unremarkable.

APPENDIX IV  
(continued)

Chemist

3

5.1. Female rat gavaged with 200 mg/kg of HCPD.

Path. Access # 77-639

Gross Pathology: Brown discoloration around nostrils was seen.  
Subpleural emphysema of the nonglandular stomach was evident.

Histopathology:

Lungs: The alveolar walls were thickened and contained macrophages and neutrophils. These changes were more intense than those seen in 77-637 and 77-638.

Stomach: The nature of changes were similar to those seen in 77-638 except that there was an intraepithelial (squamous) cyst and mild neutrophil infiltration in the squamous epithelium. Peritoneum did not show any neutrophile infiltration.

The other organs examined were unremarkable.

6.1. Female rat gavaged with 300 mg/kg of HCPD.

Path. Access #77-640

Gross Pathology: The area around nostril and anus showed brown discoloration.

Histopathology:

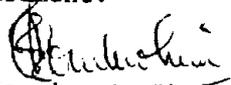
Lungs: Changes were similar to those seen in 5.1 except they are more intense.

Stomach: Changes were similar to those seen in 4.1 except that the edema in the supporting structures extends to the area in the glandular part of the stomach. The glandular epithelium was unremarkable. The squamous epithelium showed an ulcer.

The other organs examined were unremarkable.

Comments: The morphological changes indicate that a) the HCPD is absorbed through the squamous epithelium of the nonglandular part of the stomach; b) the gavage was done on animals that have been eating continuously; c) the major route of elimination of the HCPD is through lungs. It is unfortunate that no consultations were held with people knowledgeable in matters of rat gastric transit times and the gastrointestinal physiology. The local effects in the squamous part of the stomach indicate that the HCPD is highly irritant if not a mild caustic. From the morphologic changes, I venture to predict that the gastric absorption of HCPD simulates that of the alcohol. The pulmonary changes indicate interstitial pneumonia with absolutely no alveolar alterations.

Suggestion: I urge you to consult with others who might be able to help improve the design and execution of animal experiment.

  
Choudari Kommineni, Ph.D., D.V.M.



APPENDIX V

# MEMORANDUM

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE  
PUBLIC HEALTH SERVICE  
CENTER FOR DISEASE CONTROL  
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

TO : Chemist  
(Fred Phipps)  
Clinical and Biochemical Support Section, BSB  
Through: Chief, BSB *WV*

DATE: February 8, 1978

FROM : Research Veterinary Medical Officer

SUBJECT: Pathology report on guinea pigs painted on skin with hexachlorocyclopentadiene (HCPD)

Male guinea pigs were painted on skin with HCPD and were sacrificed 24 hours after. At autopsy the lungs, liver, pancreas, kidneys, adrenal, urinary bladder, heart, skin, stomach, and small and large intestines were saved for histopathology evaluation.

1.1. Control male guinea pigs

Path. Access #77-666

Gross Pathology: None.

Histopathology:

Lungs: Focal atelectasis and pseudolymphoid follicle formation were seen.

The other organs examined were unremarkable.

2.1. Male guinea pig painted with 300 mg/kg of HCPD

Path. Access #77-667

Gross Pathology: Subcutaneous edema extending from the inguinal region to mediastinal area was seen. The lungs were highly expanded showing rib impressions on the parietal surface.

Histopathology:

Lungs: Atelectasis with thickened alveolar walls containing moderate numbers of macrophages and neutrophils.

Skin: The covering squamous epithelium was one cell thick. No hyperkeratosis or mitotic activity or necrosis of any epithelial cells was seen. Moderate edema disrupted the collagen bundles. Focal pockets of neutrophils were seen in the edematous dermis. This edema also extends throughout the thickness of the adipose tissue layer. The muscle and the dermal adnexa were unremarkable.

APPENDIX V  
(continued)

Chemist

2

Kidney: Multifocal mineral deposits were seen mostly in the cortex.

The other organs examined were unremarkable.

3.1. Male guinea pig painted with 600 mg/kg of HCPD

Path. Access #77-668

Gross Pathology: Subcutaneous edema. See 2.1.

Histopathology:

Lungs: The changes were similar to those seen in 2.1 except that they were more marked.

Skin: The changes were similar to those seen in 2.1 except that they were more marked. In addition, medium size veins situated deep in the dermis showed thrombosis (partial).

Kidney: See 2.1.

The other organs examined were unremarkable.

4.1. Male guinea pig painted with 1200 mg/kg of HCRD

Path. Access #77-669

Gross Pathology: Animal was found dead; trachea had frothy fluid.

Histopathology:

Lungs: Intense congestion of all blood vessels with occasional alveolar edema.

Skin: No changes; probably sampling error. We will reembed wet tissue and evaluate. We will inform you of the results only if they are different from the above.

Kidney: See 2.1.

Liver: Focal coagulative necrosis with dystrophic calcification.

The other organs examined were unremarkable.

Comments: The HCPD was absorbed through the skin and probably eliminated through the lungs. Unlike in rat stomach, the squamous epithelium of the guinea pig skin and its adnexa did not show any necrotic changes. This is probably due to two factors, surface area and transit time.



Choudari Kommineni, Ph.D, D.V.M.

CK:ses