Health Consultation

SALINE HIGH SCHOOL

SALINE, WASHTENAW COUNTY, MICHIGAN

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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Division of Health Assessment and Consultation
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HEALTH CONSULTATION

SALINE HIGH SCHOOL

SALINE, WASHTENAW COUNTY, MICHIGAN

Prepared by:

Michigan Department of Community Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry
U.S. Department of Health and Human Services

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Abbreviations and Acronyms

ABG	arterial blood gas
ACGIH	American Conference of Governmental Industrial Hygienists
AEGL	Acute Emergency Guideline Level
ASHRAE	American Society for Heating, Refrigerating and Air Conditioning Engineers
ATSDR	Agency for Toxic Substances and Disease Registry
CO	carbon monoxide
CO_2	carbon dioxide
EPA	Environmental Protection Agency
eV	electroVolt
GI	gastrointestinal
H_2S	hydrogen sulfide
HVA	Huron Valley Ambulance
HVAC	Heating, Ventilation and Air Conditioning
kg	kilogram
L	liter
%LEL	percent lower explosive limit
m^3	cubic meters
MCL	maximum contaminant level
MDCH	Michigan Department of Community Health
MDL	method detection limit
mg	milligram
MPI	mass psychogenic illness
MRL	minimal risk level
NAC	National Advisory Committee
NEI	Nova Environmental, Inc.
NFIRS	National Fire Incident Reporting System
NIOSH	National Institute for Occupational Safety & Health
$\%O_2$	percent oxygen
OEHHA	Office of Environmental Health Hazard Assessment
PCC	Poison Control Center
PEL	permissible exposure limit
ppb	part per billion
ppm	part per million
PTFD	Pittsfield Township Fire Department
PTPD	Pittsfield Township Police Department
REL	recommended exposure limit
SCBA	self-contained breathing apparatus
SHS	Saline High School
SME	Soil & Materials Engineers
THM	trihalomethane
TLV	threshold limit value
µg	microgram

VOC	volatile organic chemical
WCDPH	Washtenaw County Department of Public Health
WCHMRT	Washtenaw County Hazardous Materials Response Team
WISER	Wireless Information System for Emergency Responders

Summary

A multidisciplinary investigation was initiated at Saline High School (SHS) in September 2005 following several consecutive days of apparently clustered illnesses that led to two building evacuations within one school week. Several types of air sampling, water sampling, and an epidemiological investigation were conducted. MDCH specifically examined all data to determine if there was a chemical agent responsible for the reported health effects. No apparent health hazard was found at this site (i.e. no biological or chemical causative agent was linked to the reported health effects). The overall conclusion of the multidisciplinary group was that an "outbreak" of mass psychogenic illness, spread by "line of sight" transmission, was the most likely explanation.

Purpose and Health Issues

The purpose of this document is to report and interpret the results obtained from a joint public health/environmental investigation that was conducted at SHS, Washtenaw County, Michigan. Local first responders (township and county), Environmental Protection Agency (EPA), Michigan Department of Community Health (MDCH), Washtenaw County Department of Public Health (WCDPH) and local environmental and engineering consultants acted collectively to analyze environmental media (water and indoor air), engineering features of the building, and epidemiological data in response to a series of unexplained adverse health effects among students. The specific role of MDCH was to collect data from the various investigation partners, determine if chemicals were present and, if so, in what quantities, and determine whether the observed health effects may be due to chemical exposures. To determine if there was a scientifically plausible link between exposure and health effects, MDCH compared the analytical and epidemiological data to established comparison values and known health effects of the potential chemical contaminants.

Background

The events of the final week of September 2005 at SHS led to a multidisciplinary analysis and multi-agency investigation involving medical experts, chemical exposure experts, clean-up contractors, federal and state agencies, and engineering and construction experts. SHS is located in the southeastern portion of the lower peninsula of Michigan, approximately 10 miles south of Ann Arbor in Washtenaw County. (See Appendix A for maps of southeastern Michigan as well as the Saline area.) In September 2005, approximately 1800 students began the second full year of classes at this brand new, three-story facility. The school building is bound on all sides by property owned by Saline Area Schools, including athletic fields and parking areas (EPA 2005a). It is important to understand the chronology of events beginning on September 27th in order to appreciate the need and focus of the subsequent investigation.

Events of Tuesday, September 27, 2005

On the morning of September 27, 2005, local "first responders" (Pittsfield Township Fire Department [PTFD] and Pittsfield Township Police Department [PTPD]) were called to respond when 3 high school children became ill. Upon their arrival, 4 more students "fell ill," many from the same classroom, and all 7 (referred to as the "9/27 cohort") reported symptoms within a few hours of one another. Headache, lightheadedness, and nausea were the most prevalent symptoms recorded by WCDPH during the course of their epidemiological investigation several days later. (See Appendix B for a summary of the data from this investigation.) Two students fainted, according to the WCDPH epi data. Four (4) members of the 9/27 cohort were transported via ambulance to either the local emergency room or their personal physician. Six (6) members of the 9/27 cohort were female and all were 16 or 17 years of age.

The school was evacuated and PTPD and school officials secured a perimeter around the school while PTFD began indoor air monitoring using a standard "four-gas" meter, which measures "percent lower explosive limit" (%LEL), "percent oxygen" (%O_2) hydrogen sulfide (H_2S) concentration, and carbon monoxide (CO) concentration. All readings from this meter were within acceptable limits and PTFD stated "no abnormal readings" in their NFIRS (National Fire Incident Reporting System) report. The air handling system was shut down and an external inspection was conducted to confirm the absence of obvious signs of tampering and/or introduction of chemicals through outside air intake vents. Interviews were conducted by the Incident Commander (from PTFD) with school officials and other staff to rule out current construction and/or cleaning processes, chemistry class experiments, and any reported leaks or spills as a cause of chemical exposure. Huron Valley Ambulance (HVA) staff were consulted as to whether or not they thought illicit drug use was a possible cause of the reported adverse health effects, specifically "huffing" (the inhalation of volatile organic chemicals, or VOCs, from a paper bag or other device). HVA staff "felt this to be an unlikely cause of the problem" (as stated in the PTFD NFIRS report). At this time, a request for technical assistance was made to the Washtenaw County Hazardous Materials Response Team (WCHMRT).

WCHMRT and its monitoring and response resources arrived on scene and was briefed by PTFD prior to entering the building with several different types of air monitors in "Level B" personal protective gear. (Level B is defined as a positive-pressure, full-face self-contained breathing apparatus [SCBA], hooded chemical-resistant, inner and outer chemical-resistant gloves, steel-toed boots with chemical-resistant covering, and a hard hat.) A four-gas meter, photoionization detector, sorbent tubes ("Draeger tubes"), and a hand-held ion mobility spectrometer (specifically, the Advanced Portable Detector 2000, "APD2000") were used to analyze indoor air in 19 rooms from all floors of the high school. (See Appendix A for a floor plan layout for each of the three floors of SHS.) According to the WCHMRT NFIRS report, "no levels of chemicals [were] detected within the building" and it was "recommended to the Superintendent of Schools to contact an independent company to conduct air monitoring/sampling." This latter recommendation was also given by PTFD, and school officials immediately retained the consultant Nova Environmental, Inc. (NEI) to perform continued medium-term

monitoring of indoor air and other duties as assigned. WCHMRT re-entered the building "with street clothes and no breathing apparatus at all" and "did not smell anything or find anything on monitors" (WCHMRT 2005).

NEI arrived during the afternoon of September 27 and conducted visual inspection of several classrooms and additional air monitoring in two classrooms (one on the 1st floor and one on the 2nd floor). The visual inspection revealed no obvious pollutant sources and "no elevated levels of contaminants" during the air monitoring. (NEI 2005)

Events of Wednesday, September 28, 2005

Sixteen (16) kids (the "9/28 cohort") reported feeling ill, with predominant symptoms being headache, dizziness, and light-headedness. Many of these cases were from a classroom implicated on Tuesday (Room C225/General Science room) and twelve of the cases were reported roughly during the same time period as the 9/27 cohort (~ 9 a.m. through 12 noon). Several individuals of the 9/28 cohort described the symptoms as coming on as "they were discussing the events from Tuesday." No students reported fainting to WCDPH and no students were taken off-site for medical evaluation. Twelve of the 9/28 cohort were female with ages ranging from 13 to 17.

According to NEI (2005), the "classroom was immediately evacuated" and NEI was "called back on-site" to discuss potential issues with the heating, ventilation, and air conditioning (HVAC) system as well as future strategy. At this time, it was decided that Room C225 would remain vacant and monitoring would be done there and in adjacent areas of the school building during the evening of 9/28/05 and on 9/29/05. Additionally, architectural, engineering, construction, and maintenance staff would conduct a thorough investigation of the HVAC system.

Events of Thursday, September 29, 2005

Six (6) students (the "9/29 cohort") reported symptoms between 8 a.m. and 11 a.m., half of which were in Room C115 (and an additional one in Room C111). Headache and lightheadedness were the predominant symptoms with two students reporting they fainted in Room 115 during this time. These students were twins and both also experienced blurry vision that rapidly resolved (a unique symptom that was not reported by any other students). Five of the 9/29 cohort sought medical evaluation at the local emergency room or private physician. Four of the 9/29 cohort were female with ages ranging from 14 to 16.

Both PTFD and WCHMRT were called to the scene between 10:30 and 11 a.m. Again, the incident command structure was led by PTFD and given the chronology of events to this moment, PTFD ordered the school evacuated for the second time that week. (The school day was cancelled after this evacuation and arrangements made to get the students home.) PTFD assisted with evacuation of some students and removal of patients who fainted. Again, PTFD sought technical assistance from WCHMRT.

NEI was already on-site during the morning of 9/29 to perform their monitoring operations in Room C225. Upon the evacuation orders, their instrumentation was relocated to the first floor, where monitoring was done in Room C115 and the adjacent hallway for "approximately ten minutes until the HAZMAT team instructed them to vacate the building" (NEI 2005). WCHMRT arrived with their monitoring resources and proceeded to set up a series of monitoring stations in the school using a multi-sensor (photoionization and electrochemical detection) instrument (the "AreaRAE" by RAE Systems, Inc.). The AreaRAE looks for the typical four-gas meter substances (%LEL, CO, H_2S, $\%O_2$) and combines this with a 10.6 eV photoionization detector to look for other organic vapors. Again, WCHMRT reported no "smells and no reading on the monitors" (WCHMRT 2005).

After the second evacuation, request was made to the WCDPH for their Medical Officer to deploy to the scene for consultation. The first of two multidisciplinary meetings (including school staff, PTFD, WCHMRT, and NEI) of the day was held upon the arrival of WCDPH staff, where it was decided that assistance would be requested from both EPA and MDCH. The EPA Emergency Response Branch office at Grosse Ile, Michigan, and staff from the MDCH Chemical Terrorism and Emergency Preparedness Section were contacted.

Prior to deploying to the school, MDCH staff consulted two emergency resources: the Detroit area Poison Control Center (PCC) and the "Wireless Information System for Emergency Responders" (WISER). WISER is a system designed to assist first responders in hazardous material incidents and provides a wide range of information on hazardous substances, including substance identification support, physical characteristics, human health information, and containment and suppression advice. One feature of WISER allows the user to enter signs and symptoms (as well as physicochemical and other attributes) to generate differential lists of potential chemical exposures. The limited information given to MDCH (no odor, dizziness, headache) prior to the meeting described below was entered into WISER and two broad classes of exposures seemed to emerge: volatile organic solvents (VOCs) and asphyxiants. Consultation was then done with the PCC who not only confirmed these two classes as potential causative agents, but offered some other very valuable advice as well:

In the opinion, of PCC staff,

- The investigation should focus on the 9/27 cohort.
- Simple (as opposed to chemical) asphyxiants appear to more likely, including chemicals such as acetylene, helium and other noble gases, Freons, nitrogen compounds, and cleaning products used as inhalants (such as the computer keyboard cleaner "Dustblaster," which is used as a drug of abuse - a process called "huffing").
- Sources within a school for these compounds could include gas jets, refrigerators and other mechanisms leaking Freon[1], dry ice from theater class, generators, furnaces and HVAC systems, and substances found in art or shop class. (In fact,

[1] Freon is a registered trademark of DuPont.

some of the rooms on the first floor of the school where symptoms were observed were art rooms.)

- Chemical exposures were a possibility, but at the time of the consult, the PCC did not feel that either food-borne illness or mass psychogenic illness were completely ruled out.

Upon the arrival of EPA and MDCH staff, the second multidisciplinary meeting of 9/29 was held, where it was decided that:

- The school would remain closed through 9/30/2005 to allow for a rapid yet thorough evaluation of any residual potential hazards.
- The reported signs and symptoms from those 9/27 and 9/29 cohort members that sought medical evaluation was most likely related to syncopal episodes ("simple faint") due to vagal nerve stimulation. The WCDPH Medical Officer came to this conclusion based on interviews with local hospital staff that evaluated the students as well as inconclusive (i.e. "normal") results from toxicology screens and arterial blood gas tests (ABGs) performed on those cohort members presenting to the emergency department. In addition, there were some discussions and/or viewed videos of a somewhat graphic nature that were thought to be, in part, responsible for the vagal reaction. One was a staff member recounting the details of a car accident to students and one was a video shown to a Psychology class that discussed a man getting a piece of metal through his head. The recommendation of the Medical Officer was to continue to rule out all causes, including potential chemical exposures.
- EPA would provide Summa canisters and other air monitoring equipment to do more intensive and inclusive air monitoring on 9/30/2005 (in conjunction with NEI and WCHMRT) between 10 a.m. and 12 noon, during which a majority of the 9/27 cohort and the 9/29 cohort reported signs and symptoms. Analytes were selected partially based on reported signs and symptoms and done in conjunction with MDCH staff. Data from this monitoring would be provided to MDCH staff for rapid analysis upon receipt.
- NEI would conduct further air monitoring in select classrooms, with all data collected by NEI to be provided to MDCH staff for analysis. Initial discussions concerning long-term monitoring decided that NEI and Soil & Materials Engineering, Inc. (SME) would collect additional environmental data to be provided to WCDPH and MDCH for analysis. These discussions continued via telephone and electronic mail for several days.
- The WCDPH Epidemiologist and Preventive Medicine Resident would conduct a thorough interview process with the students (i.e. conduct an epidemiological investigation). Input on the design of the interview questions was sought from MDCH staff during this meeting.
- The WCDPH Medical Officer would arrange for the school nurse to have "direct telephone access to an Emergency Department physician for immediate consultation regarding any acute symptom manifestation once the building was re-opened" (NEI 2005). In addition, the Medical Officer stated he would stay in daily contact with the school nurse until they felt this was no longer needed.

Events of Friday, September 30, 2005

Water samples were collected by SME and NEI. EPA performed sampling in Rooms C111, C115, and C225 using low-flow air sampling pumps with charcoal sampling tubes. Sampling pumps were also installed in Rooms C227 and C246 (which was considered the "background" location). "Grab" samples were collected from Rooms C115 and C225. Finally, EPA requested MDCH be present to address chemical exposure issues for the agency at a press conference to be held October 1, 2005.

Events of Saturday, October 1, 2005

All the data collected by EPA on 9/30 was rapidly analyzed by the laboratory used by EPA and was forwarded to MDCH staff by early afternoon, 10/1. All detectable concentrations of analytes were compared against the most relevant exposure standards and a summary of MDCH conclusions was distributed via electronic mail to MDCH management, WCDPH, NEI, EPA, and EPA's contractor. A more detailed discussion of the data collection and results is found later in this health consultation.

This emergent data collection and analysis was essential to the decision made to re-open school on Monday, October 3, 2005. This was announced at a press conference held at the Saline Area Schools offices during the late afternoon of 10/1. In addition, preliminary results of the overall investigation were shared with the public and media. Final results and expected follow-up activities were announced to a parent-teacher group at Saline High School later the following week (on 10/5/2005).

No environmental data generated in this process led any of the experts involved to believe that there was a chemical exposure component to the signs and symptoms of the 9/27 cohort, the 9/28 cohort, or the 9/29 cohort. It was announced at the press conference and at the parent-teacher meeting that the most likely explanation of the collective cohorts supposed symptomatology was "mass psychogenic illness." This condition is characterized by symptoms, occurring among a group with shared beliefs and symptoms that suggest organic illness, but have neither identifiable environmental cause nor clinical or laboratory evidence of disease (Jones 2000).

Discussion

Environmental Sampling and Data

Air data

The approach of air monitoring done by EPA on 9/30 was to "rule out chemical specific hazards that the EPA had [the] ability to monitor for in real time" (EPA 2005b). A portable hand-held instrument measured in "real time" for hydrogen cyanide, chlorine, phosphine, ammonia, VOCs and lower explosive limit. "Real-time data" was collected three times per room in C111, C115, C225, C227, and C246 between 9 a.m. and 1 p.m. (15 total samples) and all were "non-detect" at a method detection limit (MDL) of 0.5

ppm (i.e. all samples were less than 0.5 ppm and, therefore, are non-detects). Mercury air analysis was performed in Rooms C115, C225, and C227 using a Lumex cold-vapor analyzer and all samples were non-detect at a MDL of about 20 ng/m^3.

Grab samples were taken via Summa canister on 9/30 in Rooms C115 and C225 (both near the air vent discharge point) and analyzed via EPA Method TO-15. This method analyzes for approximately 60 different VOCs. There were no detectable quantities of any of the TO-15 VOCs in Room C115. There were two "hits" (i.e. a quantity was detected above the MDL) in C225: acetone was found at 19 ppb and isopropanol (or isopropyl alcohol) was found at 3.1 µg/m^3.

Low-flow ("slow draw") samples were collected for approximately a three-hour period on 9/30 from about 9 a.m. to 12 noon from C111, C115, C225, and C227 with duplicates taken from both C115 and C225 (6 total slow draw samples from three rooms). These were collected with charcoal sorbent tubing and analyzed using the National Institute for Occupational Safety & Health (NIOSH) Method 1501. This method analyzes for about 35 VOCs. All six slow-draw samples came back non-detect using NIOSH Method 1501, which has an MDL of 2 µg/m^3.

At the suggestion of several agencies involved in the investigation, NEI performed continual monitoring for several weeks after the event by rotating the same collection instruments sequentially through rooms C115, C121, C127, and C227 (but not in this order). During the first three weeks, C115, C127, and C227 were monitored for carbon dioxide, carbon monoxide, temperature and relative humidity for a week each. In room C121 (Sculpture/Ceramics Room), some more comprehensive monitoring was done. Hydrogen sulfide, total hydrocarbons, and oxygen data were collected for the first three weeks plus the aforementioned items during the fourth and final week of monitoring. See Table 1 for details of continual monitoring performed by NEI.

Table 1. Schedule of recurrent monitoring performed by NEI at Saline High School, as modified from NEI (2005).

Dates of Sampling	***Measured Parameters and Location***	
	CO_2, CO, Temp., RH	***CO, H_2S, HC, $\%O_2$***
9/30/2005 to 10/7/2005	Room C227	Room C121
10/7/2005 to 10/14/2005	Room C115	Room C121
10/14/2005 to 10/21/2005	Room C127	Room C121
10/21/2005 to 10/31/2005	Room C121	Room C121

The first group of measured metrics includes carbon dioxide (CO_2), carbon monoxide (CO), air temperature (Temp.), and relative humidity (RH.). The second group includes hydrogen sulfide (H_2S), total hydrocarbons (HC), and percent oxygen ($\%O_2$).

See Table 2 for a summary of all the recurrent monitoring data taken by NEI. Carbon monoxide was not detected at any point during the continual monitoring and thus, these data are not included below. Air temperature and relative humidity were within "ranges of comfort" as established by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) and reported in NEI (2005).

The only anomaly found within the continual monitoring data is what NEI described as a "false positive."[2] On the morning of 10/4/05 in Room C227, there was a large spike in the carbon dioxide levels. For this room, the average air concentration for the week of 9/30 through 10/7 was found to be 492 ppm; however, on the morning in question, levels were seen as high as 5,000 ppm. According to NEI (2005), this "false positive" was attributed to students attending class in C227 at this time who were exhaling carbon-dioxide-rich air into the monitor (presumably to make the alarms sound off when concentrations of 4,000 and 5,000 ppm are achieved). According to ASHRAE, indoor air concentrations of carbon dioxide in excess of 1,075 to 1,125 ppm potentially indicate conditions of inadequate ventilation. In this case, it appears more likely that the elevated CO2 levels were in fact due to students and staff breathing into the instrumentation set up in Room C227.

Table 2. Summary of the continual monitoring data from Rooms C115, C121, C127, and C227.

Room Number	*CO2 Avg. (ppm)*	*CO2 lo/hi (ppm)*	*Temp. Avg. (°F)*	*RH Average*
C115	480	352/1186	71.2	48.9
C121	453	376/784	73.3	32.7
C127	453	370/1046	73.2	41.2
C227	492	368/5000	73.9	44.1

The additional four-gas data taken from C121 were, for the most part, all non-detect. A few low level hits for total hydrocarbons were detected, but all data points were below normal background (which is assumed to be about 10 ppm).

Water data

SME conducted water sampling in four locations in the high school: from the kitchen sink (near B214) and from drinking water fountains on floors 1 (near C128 and C142), 2 (near C206 and C218) and 3 (near C328 and C342). All samples were analyzed for the presence of VOCs, certain metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, and selenium), ammonia/phosphorus, nitrates and nitrites, pH, pesticides and herbicides, and coliform bacteria.

Copper was detected in all the drinking water fountains, with all samples falling between 0.34 and 0.56 mg/L, while the kitchen sink sample yielded a concentration of 1.4 mg/L. Lead was detected in the first floor drinking fountain sample only at 0.001 mg/L. The remaining metals were all not detected.

Ammonia concentrations ranged from < 0.01 to 0.23 mg/L. and phosphorus concentrations ranged from < 0.01 to 0.24 mg/L. Nitrate concentrations ranged from 0.25

[2] Technically, a false positive refers to a incorrect report of a "positive result" where one does not actually exist. In this case, false positive does not accurately reflect the reality of the sampling situation: high levels of CO_2 were detected due to exhalation on the sampling device, not because another substance was mistakenly identified as carbon dioxide by the sampling device.

to 0.36 mg/L while nitrites were not detected in any samples. Pesticides and herbicides were not detected in any sample.

Several water disinfection byproducts (trihalomethanes) were detected: bromodichloromethane at 12 µg/L, chloroform at 28 µg/L, and dibromochloromethane at 5 µg/L.

Hydrogen sulfide targeted sampling

Personal communications with NEI and school staff indicated there had been prior reports of a "sewer gas odor" from the first floor art rooms. One student reported smelling an odor on 9/28 while coming down the stairs from the second floor to the first floor, as found in the WCDPH epi data. The principal of the school also reported that both students and staff had reported an unidentified odor from the "Anatomy Room" (presumed to be C225) and the art rooms (C121, C123, C125, C127) in the past. The final deciding factor for targeted sampling for hydrogen sulfide was a "situation in the art room" (Room C121/Sculpture Room) as recounted during the second meeting on 9/29. Overnight in this room, an HVAC mechanical error led to the creation of high negative pressure in the room, so much so that it was difficult to open the door when the teacher arrived in the morning hours. This error was later characterized as "owner modification of the exhaust fan control sequence at the Art Rooms (J.R. Burhenn, TMP Associates, personal communication, 2005). A slight sulfur-like "sewer gas" odor was again noted in C121 at this time and although no student complaints were registered from this room, there were supposedly "chronic odor complaints" by the teacher. The source of what was presumed to be hydrogen sulfide was the dessication of the floor traps of the room, from the air being drawn through them as a result of the negative pressure that built up overnight.

One of the "fire department monitors" recorded a hydrogen sulfide concentration of 3 ppm (parts per million) in Room 115 (EPA 2005). WCHMRT stated this "hit" for hydrogen sulfide was found "in the art room," which could be any of the following rooms C121, C123, C125, or C127 (WCHMRT 2005). All additional data taken in September for hydrogen sulfide was non-detect with an approximate detection limit of 1 ppm. See section entitled "Comparison of Results to Exposure Standards" for discussion on comparison to acute exposure guideline levels (AEGLs). Despite the contradictory findings, MDCH staff recommended that NEI and SME conduct low-level hydrogen sulfide sampling (defined as MDL in the low ppb range) in areas where an odor had been reported to rule out possible transient hydrogen sulfide exposures. This chemical should not be found in any appreciable concentration in indoor school air if all engineering and mechanical systems are properly functioning.

On 10/12/05, SME conducted sampling for hydrogen sulfide using charcoal tubes at the art room drains of C121 and C125. Three samples (two from C121, one from C125) were collected for eight hours approximately one inch from both drains and analyzed by NIOSH Method 6013. SME staff noted a "slight smell of sewer gas in classroom 121," and it was their opinion that "traps for unused floor drains dried out and allowed sewer

gas to escape." There were no detectable quantities found at a detection limit of 0.014 to 0.016 ppm (14-16 parts per billion). The average odor threshold for hydrogen sulfide is in the range of 8-10 parts per billion, so it is possible to smell its characteristic odor without getting a positive hit from standard monitoring equipment (such as four-gas meters, etc.) and/or specialized equipment (such as the method used by SME above) (ATSDR 2004a, OEHHA 1999).

Comparison of Results to Exposure Standards

Volatile Organic Chemicals

The only detected VOCs from the the Summa and slow-draw air samples were acetone and isopropanol. Both were detected in Summa samples from Room C225. The acetone concentration was reported as 19 ppb, and the isopropanol concentration was reported as 3.1 $\mu g/m^3$.

Acetone is a common outdoor and indoor air pollutant and the level found in SHS is consistent with air concentrations found in new office buildings, which is typically 12-28 ppb (ATSDR 1994). Household chemicals, nail polish, and paint are a few indoor sources of acetone. The AEGL-1 for acetone for exposures between 10 minutes and 8 hours is 200 ppm. The AEGL-1 is defined as the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. The amount of acetone measured in the air at SHS is well below this level and is not reasonably expected to lead to any health effects at this concentration.

Isopropanol is found in many skin disinfectant and astringent products. Exposure to concentrations in excess of 3200 $\mu g/m^3$ (the acute recommended exposure level of California EPA) for an hour may lead to mild irritation of the eyes, nose, and throat (OEHHA 1999). The concentration recorded in the air at SHS is lower than this value by over three orders of magnitude is not reasonably expected to lead to any health effects.

Hydrogen sulfide

A high concentration of 3 ppm was reported from one of the first floor art rooms, which is higher than all AEGL-1 values for hydrogen sulfide. (See Table 3 below.) These AEGL values are "interim" values from 2002 and are based on the endpoint of headache among asthmatic individuals (NAC 2002).

It should be noted that although monitors did not detect hydrogen sulfide upon initial sweeps throughout the school on 9/27 and 9/29, PTFD was wearing personal protection gear that would impact the ability to smell this compound.

The hit of 3 ppm is also in exceedance of the California EPA Office of Environmental Health Hazard Assessment (OEHHA) "acute recommended exposure level" (REL), which is set at 42 $\mu g/m^3$ (or 30 ppb). Exposure to 30 ppb of hydrogen sulfide for an hour

is expected to lead to headache, nausea, and "physiological response to odor" (OEHHA 1999). This same document also reports the odor threshold to be 8.1 ppb, so in this case, it would be reasonably expected that the characteristic rotten egg odor would be noticed by many individuals at an air concentration of 30 ppb or higher.

Table 3. AEGL-1 values for hydrogen sulfide for a range of exposure times.

Exposure Time	***10 min.***	***30 min.***	***60 min.***	***4 hour***	***8 hour***
AEGL-1 (ppm)	0.75	0.60	0.51	0.36	0.33

While it is possible that brief exposures to low levels of hydrogen sulfide could result in headache and nausea, it does not explain the occurrence of lightheadedness or syncopal episodes (fainting) as the former is more associated with chronic workplace exposures while the latter occurs at a much higher concentration than found at the school. Furthermore, given the fact that no sampling efforts to date have replicated the presence of any significant quantity in the air, it is the opinion of MDCH that hydrogen sulfide exposure in the art rooms (most likely via the floor traps/drains) is not the causative agent based on the reported symptoms. Later consultation with the PCC corroborated this opinion. The data collected by SME and described above imply that levels of hydrogen sulfide were above the odor threshold but lower than the reported detection limit of 14-16 ppb. At this concentration, the physical effect would be little more than mild transient discomfort due to the unpleasant odor.

Carbon dioxide

A month of constant monitoring in four separate rooms led to a reported average for CO_2 that generally stayed within 450 – 500 ppm. These are slightly higher than outdoor ambient levels (which is expected since indoor air pollutants tend to originate outside) yet lower than the recommended "guideline for human comfort" of 700 ppm (ASHRAE 2004). The occupational exposure limits set by NIOSH (REL), OSHA (PEL), and ACGIH (TLV) are all 5,000 ppm. Acute human exposure data (upon which the occupational standard for "immediately dangerous to life and health" is based) shows that a 30-minute exposure to carbon dioxide at 50,000 ppm produces signs of intoxication, while a few minutes of exposure at 70,000 ppm and 100,000 ppm produces unconsciousness (Aero 1953, Flury and Zernik 1931, as reported in ACGIH 1971).

The reported air concentrations for carbon dioxide (even those in excess of several thousand ppm) represent little more than potentially poor ventilation at the time. The reported health effects are not reasonably expected to occur from the reported air concentrations of carbon dioxide.

Metals (Copper and Lead)

A water sample taken from the kitchen sink of the staff lunch area near Room B214 yielded a copper concentration of 1.4 mg/L. According to EPA (2002), the "action level" for copper "at the tap is 1.3 mg/L (this action level is also adopted for use in Michigan).

Copper can commonly occur in drinking water, especially if the water is corrosive (which can be due to acidic water, low mineral content or dissolved oxygen content) and the plumbing includes copper and brass elements, like fixtures, pipes, etc. (ATSDR 2004b). An "action level" is a concentration that, if exceeded, triggers treatment or other requirements that a water system must follow.

If water containing higher-than-normal levels of copper is consumed, some possible resultant health effects include nausea, vomiting, stomach cramps, or diarrhea. In fact, gastrointestinal (GI) health effects (as noted above) tend to be the most sensitive endpoint for acute oral exposure to copper (ATSDR 2004b). Nausea and vomiting are more common, usually occur shortly after ingestion, and tend to resolve rapidly.

ATSDR derived an acute minimal risk level (MRL) for oral exposure to copper based on a study that examined GI effects in adults from ingesting a copper sulfate in drinking water over the course of 2 weeks. This value is 0.01 mg copper per kg body weight per day (mg/kg/day) and represents a concentration threshold below which it is not reasonably expected that any health effects would occur (ATSDR 2004b). This same value was chosen by ATSDR as the intermediate MRL for oral exposure to copper, based on an endpoint of GI effects for adults consuming copper in drinking water for 2 months. According to ATSDR, MRLs are intended to serve "only as a screening tool to help public health professionals decide where to look more closely" and "contain a degree of uncertainty because of the lack of precise toxicological information on the people who might be most sensitive."

A single ingestion event involving consumption of a 0.5 L amount of water containing 1.4 mg/L would yield a dose of 0.012 mg/kg/day (assuming 100% GI absorption and an average bodyweight of 58 kg for 13-17 year old teenagers, per the EPA Exposure Factor Handbook of 1997). While it is unlikely that consumption of copper in SHS drinking water is causative agent for the symptoms reported in September 2005, there is the possibility that routine consumption of SHS drinking water may be implicated in any transient GI effects, most notably, nausea and vomiting. It is more likely the case that the kitchen sink (source of the copper exceedance) was not used very much prior to the sampling event and that simple flushing of the line and re-sampling would demonstrate compliance with the action level. The overall conclusion is that some additional characterization of SHS drinking water for copper water may be needed in accordance with Michigan's Lead/Copper Monitoring Program, as was also suggested by SME in NEI (2005).

Lead was detected in the first floor drinking fountain sample only at 0.001 mg/L. According to EPA (2002), the "action level" for lead (otherwise known as the maximum contaminant level, or MCL) is 0.015 mg/L (this action level is also adopted for use in Michigan). Lead can also commonly occur in drinking water if the water is corrosive and there is lead-bearing solder, pipes, or fixtures as part of the facility plumbing. The only detected sample is more than an order of magnitude lower than the action level; therefore, exposure to lead in SHS drinking water is not considered a threat to health.

Trihalomethanes

Water sampling from SHS revealed detectable concentrations of three trihalomethanes (THMs); specifically, bromodichloromethane was found at 12 µg/L, chloroform was found at 28 µg/L, and dibromochloromethane was found at 5 µg/L. THMs are formed (along with other byproducts) when chlorine or other disinfectants are used to control microbial contaminants in drinking water. According to EPA (2002), the maximum contaminant level for "total THMs" (specifically, chloroform, bromodichloromethane, dibromochloromethane, and bromoform) in drinking water is 80 µg/L. In this case, total detected THMs are 45 µg/L and, therefore, exposure to THMs in SHS drinking water is not considered a threat to health.

Plausibility of Link to Reported Health Effects

No concentrations of chemicals recorded in any of the environmental data were at sufficient concentrations to reasonably lead to adverse health effects, with possible exception of headache, nausea and physiological responses to odor (as a result of brief exposures to low levels of hydrogen sulfide). MDCH concluded that chemical exposure was not a plausible explanation for the reported cluster of illnesses.

The conclusions of the WCDPH Medical Director were as follows:

- While the students clearly experienced real physical signs and symptoms, the overall findings were not consistent with any airborne or waterborne exposure to a chemical agent
- All physical and lab exam findings were reportedly normal and all students were discharged in good health (after rapid recovery in most students) with no sequelae. Conversations with school officials and medical personnel to whom the students presented confirmed that there was some topical material shown in the classroom that triggered some physical discomfort and queasiness.
- All evidence appears to be point to a "line-of-sight phenomenon," which refers to a way that feelings and bodily symptoms are influenced by unusual things that are seen happening to others nearby (such as vomiting, shortness of breath and fainting)

Furthermore, the profile of this apparent cluster of illnesses is similar to available data on mass psychogenic illness (MPI). MPI is known by many names, including epidemic hysteria, mass hysteria, mass sociogenic illness, psychosocial casualties, , and environmental somatization syndrome, to name a few (Boss 1997, Kirk 2003). Typically, MPI symptoms can be spread rapidly via "line of sight" transmission, may be aggravated by a prominent emergency or media response, and frequently resolve after patients are removed from the environment in question (Jones 2000). "Symptoms" seen in an MPI outbreak often include syncope or hyperventilation and higher blood pressure (which is one of many factors that can lead to syncopal episodes) has been associated with the physiological sequelae of residents near past chemical spills (Bowler et al. 1994, Jones et al. 2000). This meshes quite well with the opinion of the Washtenaw County Medical Director's characterization of this event as a "line of sight phenomenon," the fact that the

school was evacuated and many public officials (including the media) showed up in response, and that most patients' symptoms resolved rapidly. Median recovery (as recorded during the Washtenaw County epidemiological investigation) was 3 hours, with a range of 5 minutes to 56 hours.

Two other pieces of evidence strongly support the MPI theory. First, it is more frequently experienced by adolescents or children, and seen disproportionately in females (as opposed to males) (Jones 2000). The epidemiologic data recorded in Appendix A shows that 72% of the "victims" were female and, for the most part, between the ages of 13 and 17. Second, the predominant symptoms seen among nine recorded incidents of MPI are headache, dizziness or lightheadedness, nausea, and abdominal cramps/pain (Jones 2000). Headache and dizziness/lightheadedness were reported by just under 80% of all the "victims." A small percentage of "victims" from past MPI events have reported syncopal episodes (4% reported fainting) and trouble with vision (7%). Again, the epidemiologic data supports this. 14% (4 teenagers) experienced fainting (syncopal episode) and 7% (2 teenagers) had rapidly resolving loss of vision/blurry vision.

Jones (2000) also catalogs some common characteristics of MPIs that are also consistent with the events at Saline High School. These include:

- Often occurs after exposure to an environmental trigger (such as sewer gas odors, rumors, or perhaps graphic discussions or videos)
- Symptoms associated with minimal physical or lab findings (as was the case with every student that presented to local healthcare facilities)
- Illness may occur with return to the environment (such as "symptoms" returning on Wednesday and Thursday following Tuesday's evacuation)
- Illness may escalate with prolonged media response (The file kept on this investigation contains at least ten local news pieces on the evacuation and number of illness doubled from Tuesday to Wednesday. See George and Higgins 2005, Kauth-Karjala 2005a, Lynch 2005 and Mathis 2005 for a sampling of print media pieces. The internet site of Detroit-area local NBC affiliate WDIV-TV ran 4-5 pieces from 27 to 29 September alone and several of these were picked up by CNN's internet site.)

Jones et al. (2000) reported another MPI event in a high school with some startling similarities to the events at SHS. Close to 200 students and faculty at a high school in Tennessee reported symptoms and the school was evacuated twice in the course of a week following a teacher reporting a "gasoline-like odor." The most common symptoms reported were headache, dizziness, nausea, drowsiness, chest tightness, and difficulty breathing. The two most commonly reported symptoms at the Tennessee high school were identical to those reported at SHS: headache (89%) and dizziness (70%) (Jones et al. 2000). The majority of the cases were female (69% in this case) and resolved quickly. Finally, Jones et al. (2000) reported relative risk of illness from the event and found that one was more likely to be ill if your sex was female, you saw another ill person, knew at least one classmate who was ill, and reported smelling a peculiar odor.

The MPI theory appears to have greater evidence supporting it than any exposure to biological, infectious, or chemical agents. Over 150 cases of MPI have been reported in the biomedical literature over the last 130 years or so and they frequently occur in schools (in fact, roughly 50% of all reported MPI events since 1872 have been in schoools), can be triggered by "bad odors," have a "negative" environmental investigation, and can recur once the complainants return to the environment in question (Bartholomew and Sirois 2000, Boss 1997, Kirk 2003).

ATSDR Child Health Considerations

Children may be at greater risk than adults from exposure to hazardous substances at sites of environmental contamination. Children engage in activities such as playing outdoors and hand-to-mouth behaviors that could increase their intake of hazardous substances. They are shorter than most adults, and therefore breathe dust, soil, and vapors found closer to the ground. Their lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. The developing body systems of an unborn child can sustain permanent damage if toxic exposures are high enough during critical growth stages. Injury during key periods of growth and development could lead to malformation of organs (teratogenesis), disruption of function, and premature death. Exposure of the mother could lead to exposure of the fetus, via the placenta, or affect the fetus because of injury or illness sustained by the mother (ATSDR 1998). The obvious implication for environmental health is that children can experience substantially greater exposures to toxicants in soil, water, or air than adults can.

The main concerns relative to children's health at Saline High School are lower body weight, which can result in higher doses per unit of body weight, and their age, which may have been a contributing factor in the "line of sight" transmission of the symptoms of a mass psychogenic illness. Given that no chemical hazards have been identified to date, there are no specific child health concerns at this time.

Community Health Concerns

On October 1, 2005, a press conference was held at Saline Area Schools offices in Saline, Michigan. Brief statements were made by the superintendent, PTFD, NEI, SME, MDCH, WCDPH, and the school's architectural firm, TMP Associates, Inc. Approximately 15 people were in attendance, with the vast majority being media representatives and school district staff (including some teachers at the high school). The only concerns raised by the community (the media is not considered part of this group) were relative to specific chemical causative agents, specifically chemical asphyxiants and VOCs.

On October 5, 2005, a Parent Teacher Organization meeting was held at Saline High School, that included a briefing to concerned parents and students to provide information that was distributed duing the press conference held on the previous Saturday. Brief presentations were given by representatives from the school, PTFD, NEI, SME, WCDPH and MDCH. Approximately 60 people (including local media) were in attendance.

The concerns raised by parents were primarily focused on specific causative factors that could have led to the reported symptoms, such as lack of proper nutrition; use or misuse of cosmetics, personal products or medications; commonly consumed food or beverages; and previous viral or bacterial infections

Officials explained that, during the course of the investigation, all of these causative factors were considered and all were ruled out. Additionally, it was explained to the audience by MDCH staff that air monitoring performed during the course of the investigation revealed very low concentrations of a few volatile organic chemicals, but that these were commonly found in indoor air and were not of a sufficient concentration to be reasonably expected to lead to any reported symptoms.

Finally, there were several concerns raised regarding emergency planning at the school. Specifically, a parent wanted to know more about how "lessons learned" from this experience would be incorporated into existing evacuation plans and other emergency response protocols.

Overall, the audience was appreciated and praised the Agency officials for a thorough and rapid response investigation (Kauth-Karjala 2005b).

Conclusions

MDCH and ATSDR conclude that no chemical or biological causative agent is linked to the symptoms reported by the students of Saline High School, and thus, there is no apparent health hazard. Review of biomedical literature on MPI, conducted via "line of sight" transmission, supports this as the most likely cause. Suggestions were made to the school administrators and their contractors as to how to prevent any future intrusions of hydrogen sulfide through the floor drains/traps. It is suggested that MDCH staff follow-up at least one more time with the school to ensure that reports of "sewer gas odor" have disappeared. Finally, MDCH will continue to be available to review any additional environmental data taken from the school, especially any water data that may be collected to further characterize the staff area kitchen sink exceedance for copper.

Public Health Action Plan

MDCH will provide this final health consultation to the Saline Area Schools group and offer to brief any staff, faculty or parents as to its conclusions.

MDCH will alert the school that we will continue to be available to review any future environmental data taken from the school. This particularly applies to the additional water data that may be collected in conjunction with Michigan's Lead/Copper Monitoring Program. While compliance with this rule is not mandatory in this case, MDCH suggests that additional sampling be performed at the source that exceeded the action level for copper (i.e. the kitchen sink from the staff lunch room near Room B214), after the line has been flushed." (It should be noted that appropriate staff from MDEQ were consulted by MDCH prior to making this suggestion.)

MDCH will perform at least one follow-up with school administrators to ensure that reports of “sewer gas odor” inside the school do not persist. One initial follow-up was conducted with the school in May 2006 and it was reported that no odor complaints were received from any of the art rooms since several of the floor drains were sealed (D. Bacon, Saline High School, personal communication, 2006). The only remaining functional floor drain that requires follow-up is the one in Room C121 (Sculpture./Ceramics). MDCH will perform one more follow-up with SHS at the beginning of next school year (in the late September 2006 timeframe).

MDCH will provide the school with a short written "one year update" for inclusion in any newsletter publications that are provided to parents. This is to reiterate the absence of known contaminants and to update parents as to MDCH actions taken after the parent-teacher meeting of October 2005."

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If any citizen has additional information or health concerns regarding this health consultation, please contact the Michigan Department of Community Health, Environmental and Occupational Epidemiology Division, at 1-800-648-6942.

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CERTIFICATION

This Saline High School Health Consultation was prepared by the Michigan Department of Community Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial review was conducted by the Cooperative Agreement Partner.

Technical Project Officer, CAT, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

Team Lead, Cooperative Agreement Team, CAPEB

Appendix A: Maps of Saline High School and surrounding area

Figure A-1. Map of the southeastern corner of Michigan, including Washtenaw County and the Detroit metropolitan area.

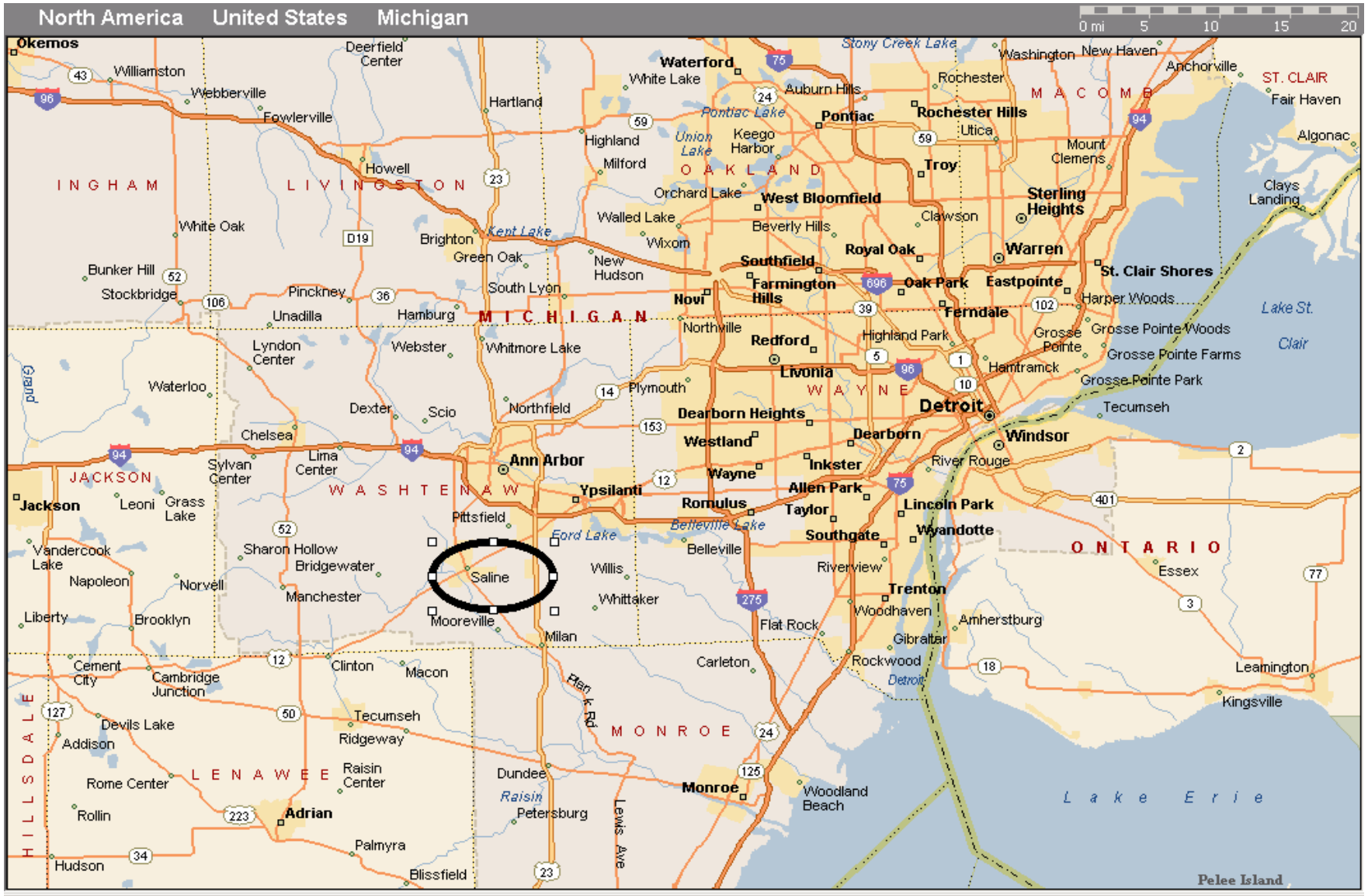

Figure A-2. Close-up of the Saline area, including location of the high school.

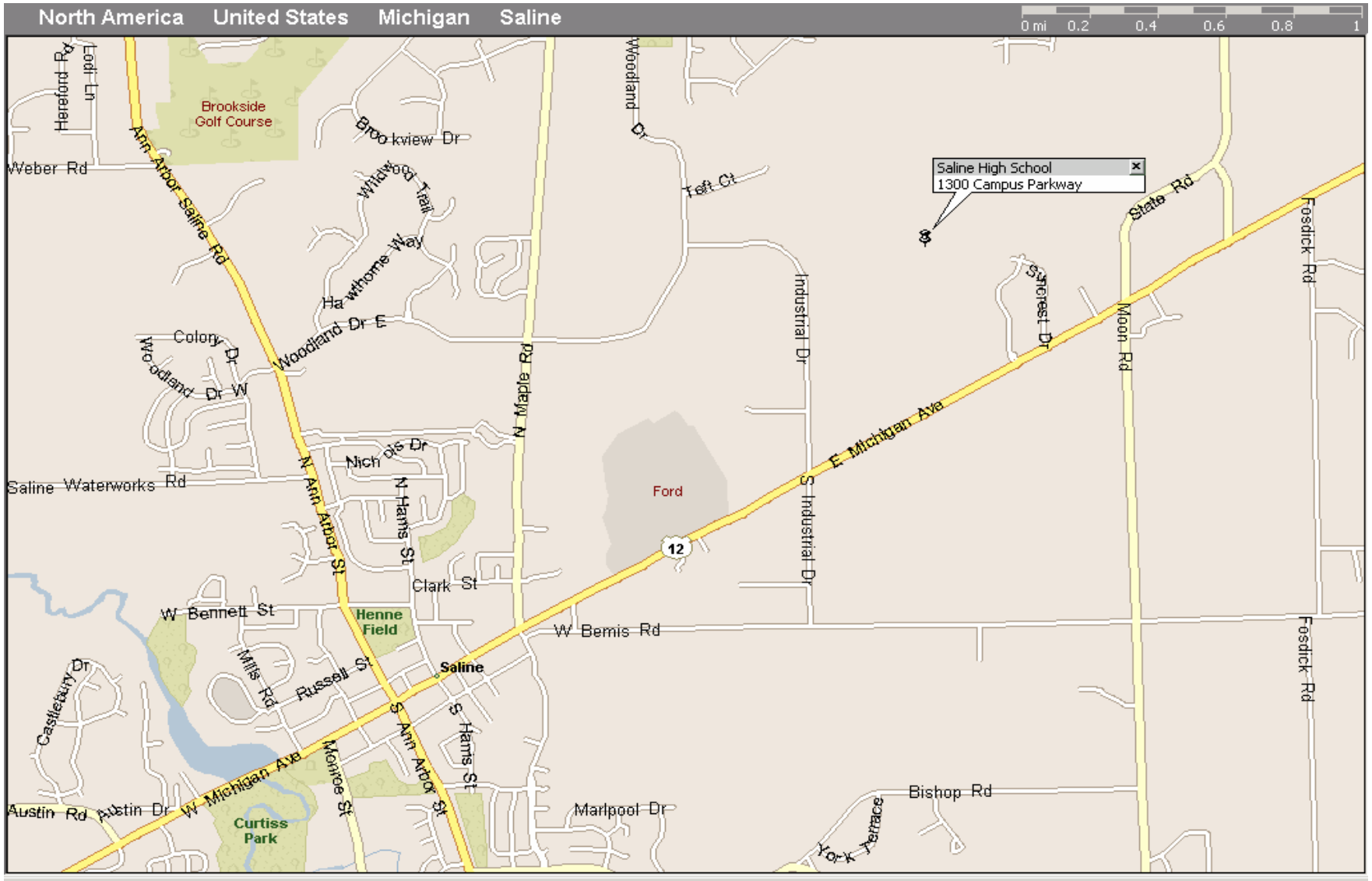

Figure A-3. Floor plan of Saline High School - 1st floor.

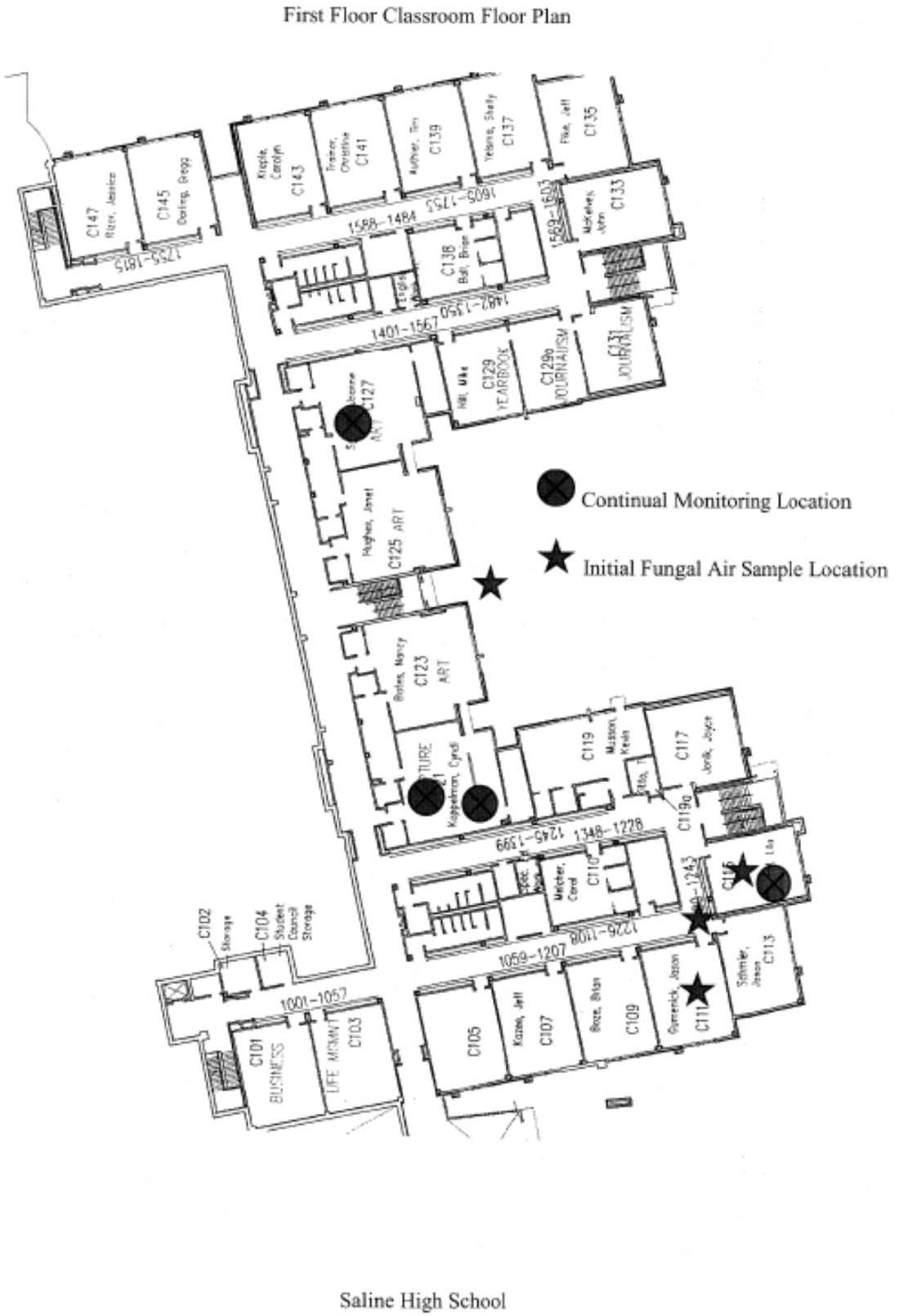

Figure A-4. Floor plan of Saline High School – 2nd floor.

Figure A-5. Floor plan of Saline High School – 3rd floor.

Appendix B: Saline High School Apparent Illness Cluster Event

Saline High School Incident – Summary
October 1, 2005
Washtenaw County Department of Public Health

Interview process:
Washtenaw County Public Health was given a list of students (total = 28) who were identified by school officials as having been sick with similar symptoms during the 3 days (September 27 – 29). Public health staff contacted parents/guardians of students by phone to request permission to speak with students. All interviews were conducted on 9/30/05 or 10/1/05. Three interviews were not completed: one parent refused, one family was unreachable, and one student did not want to speak with PH staff.

	Number	Percent (of total interviewed)
Students interviewed	25	
Age:		
13 yr	1	4%
14 yr	3	12%
15 yr	4	16%
16 yr	9	36%
17 yr	8	32%
Grade:		
9	6	24%
10	1	4%
11	7	28%
12	11	44%
Gender: Male	7	28%
Female	18	72%

25 ill students + 4 students ill 2 days = 29 illness events

	Number	Percent (of total illness events)
Students sick on Tuesday	7	24%
Students sick on Wednesday	16	55%
Students sick on Thursday	6	21%

Tuesday:
Illness onset times were 9:00 – 11:30am.
Location: Mr. Loveland's class 2nd floor (1); Rm 243 (1); Rm 111 (1); Rm 225 (4)

Wednesday:
Illness onset times were 8:30am – 2pm.
Location: Rm 210 (1); Mr. Loveland's class 2nd floor (1); Dr. Jastrow 2nd hour (1); Mr. Smigelski's class (1); Rm 229 (1); getting off stairs onto 2nd floor (1); Rm 225 anatomy (5); rm 207 (1); gym/track (1); Rm 201 (1); hallway 2nd floor (1); Rm 341

Thursday:
Illness onset times were 8am – 10:40am.
Location: Homeroom (1); Mr. Waziniak's class 3rd floor (1); room 111 (1); room 115 (3)

Table: Symptoms

	Number	Percent (of total illness events = 29)
First symptom:		
Headache	10	34%
Dizzy/lightheaded	12	41%
Felt warm	3	10%
Blurred vision	1	3%
Other	3	10%
Headache	23	79%
Dizzy/lightheaded	23	79%
Nausea/upset stomach	9	31%
Felt hot	8	28%
Sweating	5	17%
Tingling in hands, feet, body	8	28%
Shaking	8	28%
Fainting/passing out	4	14%
Blurred vision	4	14%
Eyes burning	3	10%
Felt cold	2	7%

Environmental factors

	Number	Percent (of total illness events = 29)
Strange smell	1	3%
Saw other student sick first	15	52%
Upset or worried	9	31%

Note: Almost all of the students who reported being upset/worried at the time of their illness onset were concerned about what had happened to other students. On Wednesday in Anatomy class, students started getting symptoms again as they were telling the teacher about what happened on Tuesday. None of the students reported being upset by the description given by the substitute teacher about his car accident. None of the students reported being upset about the movie showing the reenactment of the man with the rod into his brain.

Medical care

	Number	Percent (of total illness events = 29)
Saw School Nurse	19	66%
Ambulance/paramedic	7	24%
ER	8	28%
Family MD	5	17%

Took medication	13	45%
Motrin/Tylenol	10	34%
Prescription Rx	3	10%

Recent illness:
6 students reported illness during the previous week (5 were cold/URI symptoms and the other was headache/dizziness)

Recovery time:
Range = 5 minutes to 56 hours
Median = 3 hours