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JOSEPH E. CONNARTON
CITY CLERK

JOHN E. FLYNN
DEPUTY CITY CLERK

April 9, 1990

TO: The Honorable, The City Council:

FROM: Mr. Joseph E. Connarton, City Clerk *JEC*

SUBJECT: CRLS/Air Quality Reports

Pursuant to the request of her honor the Mayor, I am forwarding to each of you the enclosed reports of two health studies completed at CRLS.

I hope you will find this information beneficial.

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enclosure

MEMORANDUM

TO:

Joseph Connarton, City Clerk

DATE:

April 6, 1990

FROM: James M. Connors, Executive Director for Management Services

SUBJECT: Air Quality Project Reports for City Council:

As requested, attached are 10 copies of the major reports received by the School Committee relating to the CRLS Air Quality Project. These were distributed in January throughout the school system and elsewhere as indicated.

Please contact me at 498-9253 if you need additional information. Thank you.

JMC/tg

cc: C. Rodley
M.L. McGrath

CAMBRIDGE SCHOOL DEPARTMENT

159 THORNDIKE STREET
CAMBRIDGE, MASSACHUSETTS 02141

January 12, 1990

TO THE HONORABLE MEMBERS OF THE SCHOOL COMMITTEE:

AIR QUALITY REPORTS

Please be notified that reports entitled: "Cancer Incidence and Respiratory Symptoms at Cambridge Rindge and Latin School", and "The Assessment of Air Quality and Ventilation Systems at CRLS Complex", are enclosed for your review and will be made available at the following advertised locations for public review:

All Elementary Schools

The Main Office and House Offices at CRLS

Student Library and Teachers Resource Center at CRLS

The Main Branch of the Public Library

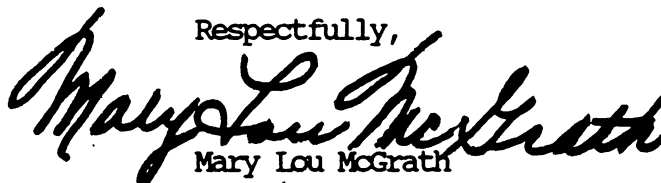
City Hall (Offices of the Mayor, City Manager and City Council)

and the School Committee Office.

Also enclosed is a letter that will be distributed to the parents of high school students and grade 8 students. This distribution is scheduled for next Tuesday, January 16th.

Copies will be distributed to the CRLS Air Quality Advisory Committee on Tuesday, January 16th.

Respectfully,


Mary Lou McGrath
Superintendent of Schools

MLM:m

Reports from Two Health Studies at
Cambridge Rindge and Latin High School

1. Cancer Incidence Among Teachers and Staff Between 1982 and 1988.

Richard Clapp¹, Sc.D. and David Ozonoff^{1,2}, M.D.

2. A Survey of the Frequency of Respiratory and Other Symptoms Among Students, Teachers, and Staff.

James H. Ware³, Ph.D., Diane Gold⁴, M.D., Amy
Chen Rundle³, M.S., and Frank E. Speizer^{3,4}, M.D.

November 10, 1989

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BACKGROUND

Occupancy of Cambridge Rindge and Latin High School (CRLS) began in 1979 and the building was fully occupied by the Spring of 1981. Almost immediately, some members of the staff began to express concerns about the quality of the indoor environment. A series of studies beginning in 1982 found that some areas of the building received an inadequate supply of fresh air. Numerous recommendations regarding improvements in the schools' ventilation system were implemented between 1984 and 1988, but many students, teachers, and other workers at the school continued to feel that the environment was unsatisfactory. Despite the conclusions of industrial hygienists that the problem at the school was inadequate ventilation rather than air pollution, some of the school's occupants continued to be concerned that their illnesses and feelings of discomfort were caused by exposure to unhealthy substances in the indoor air.

These concerns became acute in the spring of 1989 when the death of an assistant headmaster, who was initially believed to have had a primary diagnosis of brain cancer, was followed by the sudden illness of the school's headmaster, who also was initially believed to have developed brain cancer.

At this point, Mrs. Mary Lou McGrath, Superintendent of Schools for the city of Cambridge, sought the advice of an outside group of health and environmental scientists. Through several meetings with Dr. McGrath, teachers, and parents, these

advisors developed a three-part program for evaluating and correcting the problems plaguing CRLS. First, the Environmental Health and Engineering Corporation, an environmental monitoring and evaluation firm directed by Dr. John Spengler and Dr. John McCarthy, was retained to undertake a comprehensive evaluation of the building. Second, Dr. David Ozonoff of Boston University School of Medicine and John Snow Research and Training Institute and Dr. Richard Clapp, also of John Snow Institute, agreed to review data from the Massachusetts Cancer Registry to determine whether faculty and staff at CRLS had experienced unusual rates or patterns of cancer incidence since 1982, the first year in which the Cancer Registry collected data. Third, Dr. James Ware, Dr. Diane Gold, and Dr. Frank Speizer of the Harvard School of Public Health and the Harvard Medical School agreed to carry out two surveys of respiratory and other illnesses and symptoms commonly seen in buildings with air quality problems. The first of these surveys was conducted in the first week of June, 1989. The second will be administered in the Spring of 1990, after changes recommended by Environmental Health and Engineering have been implemented. This report describes the results of the study of cancer incidence rates conducted by John Snow Institute and the first health survey carried out by the Harvard scientists.

Cancer Incidence Among Teachers and Staff Between 1982 and 1988

Richard Clapp¹, Sc.D., and David Ozonoff^{1,2}, M.D.

¹John Snow Research and Training Institute, Inc.

²Boston University School of Public Health

INTRODUCTION

The Massachusetts Cancer Registry has been in operation since January 1, 1982. It seeks to gather medical and identifying information on every case of cancer diagnosed at a Massachusetts Hospital. Several studies have shown that a very high percentage, probably in excess of 95%, of cases are properly recorded. By midsummer of 1989, most cases diagnosed in 1988 had been entered to the computerized registry. This report describes all cases of cancer identified through matching of a list of names of staff members at the Cambridge Rindge and Latin High School (CRLS) to the cancer registry.

A computer tape containing the names of all persons who had worked at CRLS since January 1, 1982 was prepared in late June, 1989. It was delivered to the Bureau of Health Statistics, Research, and Evaluation of the Massachusetts Department of Public Health where staff in the Occupational Disease Surveillance Project estimated that it would take several months to do a computerized linkage of the tape with the Cancer Registry computer file. Since this would have made it impossible to analyze the data by the fall of 1989, an alternative method was pursued. The staff of the Center Registry entered the names and dates of birth (where available) manually from a computer print-out; this began as a special project in July, 1989. The results were provided to Dr. Richard Clapp in early August and a summary of the findings is presented below.

METHODS

The print-out which accompanied the CRLS staff tape included names, sex, date of birth, and dates of employment (beginning and termination) of 702 individuals. This list was entered by Cancer Registry staff and matched to computer records of cancer patients diagnosed from January 1, 1982, through approximately January 1, 1989. No information other than name was provided for 21 individuals, and date of birth was missing on 227 of the remaining 681 persons on the staff list. As a result, it was possible to identify six exact matches and seven possible matches of patients who also appeared on the staff list. Three of the patients had dates of diagnosis with cancer prior to their period of employment at CRLS. Another patient was diagnosed in 1982 with an occupation listed as "retired teacher" -- this patient was a Boston resident and did not match on date of birth.

RESULTS

The results of the matching procedures and subsequent evaluation of the possible matched patients reduces to the following list of cases who were diagnosed with cancer after January 1, 1982:

Males

Prostate cancer (2)

Oral cancer

Colo-rectal cancer

Brain cancer

Lymphoma

Females

Breast cancer (2)

Oral cancer

The cancer experience of the CRLS staff was analyzed in two ways. Because some dates of birth and dates of employment were missing on the printout, the age distribution and years of employment of the staff were estimated from data on 1/3 of the sample. The estimates of years of employment were 1,521 person-years among the 307 male staff and 2,054 person-years among the 373 female staff. Nearly all the staff were between the ages of 20 and 65 during their period of employment. Accordingly, based on statewide average rates of cancer for males and females during the mid-1980's, the number of expected cases was estimated to be 4.15 and 6.28, respectively, in CRLS staff. These data are compared to the actual number of cases reported to the Cancer Registry as follows:

<u>Sex</u>	<u>Observed</u>	<u>Expected</u>	<u>O/E</u>	<u>95% Conf. Int.</u>
Males	6	4.15	1.45	(.53 - 3.16)
Females	3	6.28	.48	(.10 - 1.40)
Total	9	10.43	.86	(.39 - 1.63)

The second method of evaluating the cases seen in CRLS staff was to calculate the proportions of cancers of specific types that would be expected based on statewide average proportions. Using the statewide data for prostate and breast cancer (the only types for which there was more than one case in either males or females), the expected numbers are 0.51 and 1.03, respectively. These expected values are compared to the numbers of cases identified in the CRLS staff below:

<u>Cancer Type</u>	<u>Obs.</u>	<u>Exp.</u>	<u>O/E</u>	<u>95% Conf. Int.</u>
Prostate	2	.51	3.92	(.47 - 14.15)
Breast	2	1.03	1.94	(.23 - 7.00)

DISCUSSION

The overall findings in this preliminary analysis of cancer incidence among CRLS staff during the period 1982-1988 do not suggest an unusual pattern of cancer in this population, either in the overall incidence of all types combined, or in any specific type. The greater than expected number of cases in males is due to the two cases of prostate cancer (when less than one was expected), but neither finding meets the usual test of statistical significance. Likewise, the two cases of breast cancer in females are more than the number that would be expected, but this is also based on only two cases.

The limitations of this study are that it is only a preliminary follow-up of the roughly 700 individuals who were reported to have worked at the school at some time during the time period. It is not known, for example, how many of the CRLS staff who retired or left employment also moved out of Massachusetts and therefore were not subject to having their cancer diagnosis reported to the state Cancer Registry. The only way to answer this question would be to mount a much larger effort to track all former employees, see how many had moved away, and then try to determine whether they had been diagnosed with cancer. This was beyond the scope of this investigation. It should be recognized, however, that expected rates were based only on years of employment at CRLS. Presumably, all or nearly all cases diagnosed during those years would have appeared in the registry.

As noted, date of birth and/or dates of employment were missing for a fairly large number of staff. The Cancer Registry staff did considerable checking of those patients who appeared to match on information that was available. Given their experience in this type of work, it is likely that all of the potential matches were found. Three were excluded from the analysis because their cancer was diagnosed before they were employed at the CRLS, and presumably had nothing to do with employment there. A fourth patient was excluded from the analysis because he did not match on date of birth and additional information on the

Cancer Registry report form suggested that he was unlikely to have worked at CRLS during the time period of this study.

Another patient who died in early 1989 was found to have been diagnosed at a Boston teaching hospital in June, 1988, but not reported to the Cancer Registry by July, 1989. He had metastatic tumors in the brain, but the primary site of cancer was apparently the lungs. Since the report had not been received at the time of this analysis, it is not included here; nevertheless, the overall picture will not change when this case is added to the registry.

It should be noted that the state Cancer Registry collects information only on malignant tumors, not benign tumors or tumors that are diagnosed at a very early stage (called in situ). There may be additional benign tumors that have been diagnosed in CRLS staff that are of concern, but they will not be reflected in data from the Cancer Registry files.

Perhaps the most critical limitation of this preliminary study, however, is its short time period. If the concern about environmental conditions at the CRLS is that they may have led to the development of cancer in the staff, the time period of most relevance is perhaps ten or twenty years from now. This is because cancer due to a specific exposure, such as some chemical or cigarette smoke (possibly in combination with a chemical) could take as many as twenty or thirty years to develop. This study was able to look at only the period 1982-1988 and may have

included primarily those cancers whose initial cause occurred in the 1950's or 1960's.

CONCLUSIONS AND RECOMMENDATIONS

This review reports on the cancer experience of CRLS employees and former employees during their periods of residency in Massachusetts. It is an attempt to answer some preliminary questions about the pattern of cancer in those diagnosed between January 1, 1982 and January 1, 1989. The method was to link a list of staff who had worked at the school at some time during the period with the reported cases on the files of the Massachusetts Cancer Registry. The linkage was successful using name and date of birth on five of the cases, and was probably successful for an additional four cases using available information. The results suggested that overall cancer incidence was not significantly different from the expected incidence, based on statewide averages, either for all types of cancer combined or any specific type. The numbers of cases of the individual types of cancer were very small, and no firm conclusions are possible. Additional years of observation or a different type of follow-up study would be necessary to estimate the pattern more precisely.

Based on the findings of this preliminary study, there does not appear to be any overall excess incidence of cancer warranting immediate investigation. A prudent step might be to

conduct a similar linkage study in another five years and to remain alert to any unusual occurrence of cancer in the CRLS staff in the meantime. The staff of the Cancer Registry are to be commended for their help in completing this project in a timely manner.

Survey of the Frequency of Respiratory and Other
Symptoms Among Students, Teachers, and Staff.

James H. Ware¹, Ph.D., Diane Gold², M.D., Amy
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¹Harvard School of Public Health

²Harvard Medical School and the Channing Laboratory, Brigham and
Women's Hospital

In the early 1970's, architects, builders, and home owners responded to the 'oil crisis' by changing the designs of new buildings to increase energy efficiency. One important change in larger buildings was an increased reliance on the recirculation of heated indoor air, with reduced intake of fresh air from outdoors, to reduce heating costs. To the same end, older buildings were renovated to seal in air and heat. This move for 'energy conservation' resulted in the creation of many 'tight' buildings, that is, buildings where indoor air, though not contaminated by industrial emissions, was perceived as stale and uncomfortable. Occupants of these buildings complained of symptoms such as runny or stuffy nose, eye irritation, cough, chest tightness, fatigue, headache and malaise.

Although this problem is relatively new, many investigators and health agencies are beginning to gather information on the health problems associated with tight buildings. Fineggan and co-workers (1), for example, surveyed occupants in nine office buildings in Britain and found that nasal irritation (22% versus 6%), eye irritation (28% versus 6%), headache (35% versus 16%), and lethargy (50% versus 14%) were more prevalent in buildings with no air recirculation than in buildings with natural ventilation. Buildings with engineering systems providing some air recirculation also had higher symptom rates than naturally ventilated buildings.

Most U.S information on building-related illness derives from health hazard evaluations conducted by federal and state

agencies rather than from formal epidemiologic studies. As Samet notes in his article on indoor air pollution (2), by the end of 1985 the National Institute of Occupational Safety and Health had completed 356 health hazard evaluations of building-related problems. Fifty percent of the building-related illnesses were believed to be due to inadequate ventilation alone. Biological contaminants, inside contaminants, and contaminants brought in from outside were other causes of building-related illness.

Epidemiologists investigating the relationship between conditions in a building and the health of the employees as a group and as individuals must work closely with engineers and industrial hygienists. The engineers and industrial hygienists can determine:

1. Whether the building is "tight". This will involve the measurement of air turnover rates, distribution of supply of fresh air, temperature, and humidity in the work spaces in the building.
2. Whether there are "significant" concentrations or sources of indoor air pollutants in the building.

The epidemiologist can evaluate:

1. The overall prevalence of irritant symptoms and symptoms of change in mental status in the building. Ideally, symptom rates are evaluated before and after changes are made to the building.
2. Whether the symptoms are clustered in particular work spaces.

3. The significance of the measured levels of pollutants and the markers of air turnover, temperature, and humidity for acute and chronic symptoms

- a. in the entire group of building occupants.
- b. in individuals who may be "sensitive"

Occupants of the Rindge and Latin High School (CRLS) in Cambridge, MA, have complained of symptoms characteristic of tight buildings since the building was completed in 1981. In May, 1989, the Cambridge Superintendent of Schools requested a comprehensive evaluation of the building leading to changes in the building designed to resolve these concerns. As part of the evaluation, investigators from the Harvard School of Public Health and the Harvard Medical School agreed to conduct an epidemiologic investigation of respiratory, irritant, and other symptoms among students and staff occupying the building. The epidemiologic study will include two separate surveys, one before any changes are made in the building, and a second after changes in ventilation and indoor environments are completed. The first survey was completed in the first two weeks of June, 1989. This report describes the symptom rates reported by students and staff in this 'baseline' survey. The second survey will be conducted at the end of the 1989-90 school year.

METHODS

Once the decision to administer a health survey had been reached, the authors of this report met to develop a questionnaire that would gather information on chronic respiratory illnesses and symptoms and the acute symptoms frequently mentioned by occupants of buildings that are inadequately ventilated. The final questionnaire included a section on respiratory illnesses and symptoms taken from a standardized questionnaire used by the Six Cities Study (3), a section on 'acute' symptoms based on questionnaires used in other studies of problem buildings, and a section for identifying rooms in which symptoms were experienced. These sections of the questionnaire were administered to both students and staff. In addition, the staff questionnaire included questions about specific sources of indoor pollutants and other aspects of the work environment that might be contributing to work discomfort.

Health surveys were distributed to all 9th, 10th, and 11th graders on June 1, with follow-up distribution on June 5 and 7 to obtain questionnaires from students absent on the first day of administration. To maximize coverage, student surveys were administered during English and English as a Second Language (ESL) classes. All students at CRLS take either English or ESL. Staff questionnaires were distributed through mailboxes and places of work on June 16, and the survey was widely advertised to staff at faculty and staff meetings. Additional questionnaires were distributed to staff throughout the following week, and the School's administration made several announcements

on the School's public address system encouraging both students and staff to participate in the survey. The information collected was considered confidential and data on individuals were neither requested by nor provided to the Cambridge School Department.

The completed questionnaires were delivered in sealed envelopes to the Harvard School of Public Health, where they were entered to computer files and analyzed, using standard methods for the analysis of binary outcome data.

RESULTS

At Cambridge Rindge and Latin High School (CRLS), 1,074 (66%) of the 1,632 ninth through eleventh grade students enrolled at the school completed the health questionnaire. Average attendance during the spring days of questionnaire administration was approximately 1,410 students, so that participation rates were somewhat higher among those in attendance. Only 9 students refused to complete the questionnaire. The remaining nonresponse among those in attendance may have occurred, at least in part, because the questionnaire was not distributed in some classes.

Of the 1,074 respondents, 465 (43%) were white and 950 (88%) were nonsmokers (Table 1). In this report, symptom rates at CRLS are compared to those reported by students in grades 9-11 at Watertown (MA) High School in surveys completed between 1983 and 1985. Of 1,946 respondents at Watertown High, 1,887 (97%) were

white and 1,608 (83%) were nonsmokers. Illness rates at the two schools are examined separately for smokers and nonsmokers.

Nonsmokers at CRLS reported higher rates of all chronic symptoms and illnesses examined than did nonsmoking students at Watertown High (Table 2). In particular, CRLS students reported 3.4 times as many chest illnesses, 7.7 times the rate of chronic cough, and 3.4 times the rate of persistent wheeze. Smokers had substantially higher rates of illnesses and symptoms than nonsmokers at both schools, but rates for smokers at CRLS were uniformly higher than those of smokers at Watertown High. Rates for nonsmokers at CRLS were, in fact, roughly comparable to rates of smokers at Watertown High.

CRLS students also reported a wide range of acute symptoms characteristic of tight buildings (Table 3). One group of symptoms was considered to occur frequently if the student reported them as occurring more than once per week. Among this group, 227 (24%) of non-smoking students reported eye irritation, 273 (29%) reported sneezing, 241 (25%) reported headaches, and 341 (36%) reported sleepiness. The second group of symptoms was considered to occur frequently if the student reported that the symptom occurred at least once a month. In this group, 178 non-smoking students (19%) reported sore throats and 168 (18%) reported rash or dry or itchy skin.

Students were also asked to report whether the symptom occurred more frequently at home, more frequently at school, or with the same frequency at home and school. Of those non-smoking

students reporting a high frequency of symptoms, the percentage reporting that individual symptoms occurred either more frequently at school or with equal frequency at home and school ranged from 84% to 98% (Table 4). Thus, few students reported that their symptoms occurred more often at home. The percentage of students reporting that a symptom occurred more frequently at school ranged from 26% (runny or stuffy nose) to 72% (sleepiness).

Of the 449 members of the faculty and staff employed at the time of the survey, 264 (59%) completed health questionnaires. This report describes results separately for a) teachers and administrative staff, and b) other staff. Despite possible differences in socioeconomic background between the two groups, their survey results are quite similar.

A total of 164 questionnaires was obtained from teachers and administrative staff. Of these, 151 (92%) were of white (Caucasian) race and 147 (90%) were nonsmokers (Table 5). Of 100 other staff members completing the questionnaire, 82 (82%) were white and 81 (81%) were nonsmokers. A higher percentage of the other staff respondents (69%) were female.

Symptom rates are reported here for nonsmokers, the group of smokers being too small to consider separately. Rates of reporting of chronic respiratory illnesses and symptoms were substantially higher among both groups of faculty and staff than among students (Table 6). For example, 101 faculty and administrative respondents (69%) reported a history of colds

during the past year and 91 respondents (62%) reported chest illnesses, with 82 of these (56%) reporting that the illnesses were accompanied by lower respiratory symptoms and 58 (39%) reporting two or more chest illnesses lasting one week or more during the past year. Rates of chronic cough (37%) and persistent wheeze (30%) were also higher than would be expected in a group of nonsmoking adults. Rates of these chronic respiratory illnesses and symptoms were also high among other staff (Table 6B), though slightly lower than the rates among teaching and administrative staff.

Table 6 also displays the rates of four of these symptoms among nonsmoking participants in the Six Cities Study, a large prospective study of the health effects of air pollution (3). The form of the chronic symptom questions was identical in the two studies, but the Six Cities Study drew a random sample of adult residents in each of the communities under study. Thus, the two samples are not strictly comparable, but the Six Cities Study does provide an approximate point of comparison for symptom rates.

Tables 7 and 8 give the data on acute symptoms among teachers and administrative staff, while Tables 9 and 10 give the same data for other staff. Acute symptoms were reported with high frequencies by teachers and administrative staff (Table 7). In particular, 40% of this group reported eye irritation at least once per week, 37% reported runny or stuffy nose, and 50%

reported sleepiness. Rates of sore throat, hoarseness, and skin problems ranged from 35% to 41%.

Among those reporting these symptoms, most reported that the symptom occurred more frequently at school (Table 8). For example, 81% reported that eye irritation occurred more often at school, 78% reported that sleepiness occurred more often at school, and 84% made this report for hoarseness.

Essentially the same pattern was seen among other members of the staff. Most symptom rates were similar in the two groups (Table 9), though few in the other staff group reported chest tightness, nausea, or shortness of breath. Rates of sore throat and hoarseness were also somewhat lower in this group. The two groups were quite similar in their response to questions on the setting where symptoms were more frequent. At least 98% of other staff respondents reported that their symptoms occurred at least as frequently at school, while 40% to 100% reported that the symptoms occurred more frequently at school (Table 10). For the commonly reported symptoms, 58% to 91% of respondents reported that their symptom occurred more frequently at school.

DISCUSSION

This survey documented a high prevalence of chronic respiratory symptoms, irritant complaints, and complaints of headache and lethargy among the students and staff of Cambridge Rindge and Latin School. These elevated symptom rates are

consistent with reports from studies of buildings with inadequate ventilation (2), and do not, therefore, imply the presence of specific irritant or toxic chemicals. Other investigations have repeatedly shown that the pattern of symptom reports seen in the Cambridge Rindge and Latin Study can arise from the lack of fresh air and poor temperature and humidity control characteristic of tight buildings, even when measurable concentrations of specific pollutants are not present in the air. A full understanding of the environmental origins of these complaints must come, however, from the evaluation of the heating and ventilation system and indoor air quality currently being conducted by Environmental Health and Engineering. In particular, judgements about the presence or absence of specific chemical or other contaminants must await that report.

While we can say with confidence that the symptom rates at CRLS are high relative to rates among students at Watertown High School, among adult participants in the Six Cities Study, and among workers in naturally ventilated office buildings in Britain, it is not possible to judge how much higher the symptom rates of the students or staff would be if we could adjust for reporting bias. When a survey is conducted in the setting of strong concern about the health and safety of the building occupants, reporting bias may, to some extent, increase the rate of symptom reporting.

Selection bias due to nonresponse may also be a factor in the study. The symptom rates in the students should be

representative of the entire student population, since the response rate in classrooms reached by the survey was reportedly above 90%. Because the response rate among the staff was only 59%, the staff symptom rates may be influenced by selection bias. Nevertheless, the rates are substantially higher in the CRLS sample than in the Six Cities Study. In fact, the rates at CRLS remain substantially higher than those in the Six Cities sample even if nonrespondents are treated as negative responses. For example, 73 (16%) of the 449 persons on the staff at the time of the survey reported a history of chronic cough (Table 6). This rate is still three times as large as the 5% rate reported by Watertown adults participating in the Six Cities Study. This very conservative method of treating nonresponse shows that selection bias can not explain the high symptom rates reported by the staff.

In our view, this survey had two primary purposes, 1) to identify and quantify the health concerns of students and staff, and 2) to provide a baseline report against which a second survey, conducted after engineering changes are made, can be compared. In this initial survey, both students and staff reported high rates of respiratory and other symptoms. The second survey, to be carried out in the spring of 1990, will provide an opportunity to determine whether changes arising from the evaluation of the building have led to reductions in the frequency of these symptoms.

REFERENCES

1. Finnegan MJ and Pickerny, CAC. Building related illness.
Clinical Allergy 1986; 16:389-405.
2. Samet JM, Marbury, MC, and Spengler, JD. Health effects of indoor air pollution, Part II. American Review of Respiratory Diseases 1988; 137:221-242.
3. Ferris, BG Jr., Speizer, FE, Spengler, JD, et al. Effects of sulfur oxides and respirable particles on human health: Methodology and demography of population in study. American Review of Respiratory Diseases 1979; 110:525

Table 1. Characteristics of Student Respondents at Cambridge Rindge and Latin School, Grades 9-11

<u>Total</u>	n = 1,074
	<u>No. (%)</u>
<u>Race</u>	
White	465 (43)
Black	324 (30)
Asian	55 (5)
Hispanic	108 (10)
American Indian	4 (0.4)
Other	108 (10)
Unknown	10 (1)
<u>Sex</u>	
Male	516 (48)
Female	555 (52)
Unknown	3 (0.3)
<u>Smoking Status</u>	
Smoker	97 (9)
Nonsmokers	950 (88)
Unknown	27 (3)

Table 2A. Numbers and Percentages of 9-11th Grade Nonsmoking Students at Cambridge Rindge and Latin (CRLS) and Watertown High Schools Reporting Chronic Respiratory Symptoms or Illnesses

	<u>1989</u> <u>CRLS</u> (n=950)	<u>1983-1985</u> <u>Watertown</u> (n=1,608)
	<u>No. (%)</u>	<u>No. (%)</u>
Chest Colds	421 (44)	460 (29)
Bronchitis	70 (7)	68 (4)
Chest Illnesses	259 (27)	132 (8)
With LR [*] Symptoms	201 (21)	75 (5)
Two or More ⁺	108 (11)	24 (1)
Chronic Cough	215 (23)	54 (3)
Persistent Wheeze	258 (27)	131 (8)

* Lower Respiratory

⁺Two or More Chest Illnesses with Lower Respiratory Symptoms

Table 2B. Numbers and Percentages of 9-11th Grade Smoking Students at CRLS and Watertown High Schools Reporting Chronic Respiratory Symptoms or Illnesses

	<u>1989</u>	<u>1983-1985</u>
	<u>CRLS</u>	<u>Watertown</u>
	(n=97)	(n=325)
	<u>No. (%)</u>	<u>No. (%)</u>
Chest Colds	60 (62)	151 (46)
Bronchitis	12 (12)	31 (10)
Chest Illnesses	44 (45)	65 (20)
With LR [*] Symptoms	35 (36)	41 (13)
Two or More ⁺	21 (22)	11 (3)
Chronic Cough	39 (40)	47 (14)
Persistent Wheeze	46 (47)	71 (22)

* Lower Respiratory

⁺Two or More Chest Illnesses with Lower Respiratory Symptoms

Table 3. Numbers and Percentages of Nonsmoking CRLS Students Reporting Acute Symptoms

(n = 950)

	Number <u>Responding</u>	Number (% of 950) <u>Positive</u>
<u>Group 1: Positive if Occurring More Than Once per Week</u>		
Eye Irritation	575	227 (24)
Runny/Stuffy Nose	618	155 (16)
Sneezing	632	273 (29)
Chest Tightness	274	36 (4)
Shortness of Breath	360	70 (7)
Nausea	337	49 (5)
Headache	636	241 (25)
Sleepiness	599	341 (36)
Difficulty Concentrating	409	141 (15)
Tense/Nervous	441	156 (16)
<u>Group 2: Positive if Occurring At Least Once per Month</u>		
Sore Throat	500	178 (19)
Hoarseness	280	74 (8)
Rash, Dry Skin	303	168 (18)

Table 4. Proportion of Nonsmoking Students Reporting That Symptoms Occur More Frequently or at Least as Frequently at School As Compared to Home for those Reporting a High Frequency of Symptoms

		At least as Frequently <u>At School</u>	More Frequently <u>At School</u>
<u>Group 1</u>		<u>No. (%)</u>	<u>No. (%)</u>
Eye Irritation	(n=227)	211 (93)	130 (57)
Runny/Stuffy Nose	(n=155)	142 (92)	40 (26)
Sneezing	(n=273)	241 (88)	91 (33)
Chest Tightness	(n=36)	32 (89)	16 (44)
Nausea	(n=49)	46 (94)	35 (71)
Headache	(n=241)	232 (96)	149 (62)
Sleepiness	(n=341)	327 (96)	244 (72)
Concentration	(n=141)	138 (98)	78 (55)
Tense/Nervous	(n=156)	153 (98)	79 (51)
<u>Group 2</u>			
Sore Throat	(n=178)	149 (84)	51 (29)
Hoarseness	(n=74)	68 (92)	23 (31)
Rash, Dry Skin	(n=168)	156 (93)	56 (33)

Table 5. Characteristics of 1) Faculty and Administrative Staff and
2) Other Staff Respondents at Cambridge Rindge and Latin
School

	Faculty and Administrative <u>Staff</u>	Other <u>Staff</u>
<u>Total</u>	n = 164 <u>No. (%)</u>	n = 100 <u>No. (%)</u>
<u>Race</u>		
White	151 (92)	82 (82)
Other	13 (8)	16 (16)
Unknown	0	2 (2)
<u>Sex</u>		
Male	80 (49)	31 (31)
Female	84 (51)	69 (69)
<u>Smoking Status</u>		
Smoker	14 (9)	18 (18)
Nonsmoker	147 (90)	81 (81)
Unknown	3 (2)	1 (1)

Table 6A. Numbers and Percentages of Nonsmoking Teachers and Administrative Staff Reporting Chronic Respiratory Illnesses and Symptoms (n = 147)

	<u>No. (%)</u>	<u>Other Studies</u> <u>(%)</u>
Colds	101 (69)	
Bronchitis	38 (26)	
Chest Illnesses	91 (62)	(12)
with LR [*] Symptoms	82 (56)	
Two or more ⁺	58 (39)	(5)
Chronic Cough	54 (37)	(5)
Persistent Wheeze	44 (30)	(3)

Table 6B. Numbers and Percentages of Nonsmoking Other Staff Reporting Chronic Respiratory Illnesses and Symptoms (n = 81)

	<u>No. (%)</u>	<u>Other Studies</u> <u>(%)</u>
Colds	57 (70)	
Bronchitis	13 (16)	
Chest Illnesses	42 (52)	(12)
with LR [*] Symptoms	34 (42)	
Two or more ⁺	22 (27)	(5)
Chronic Cough	19 (24)	(5)
Persistent Wheeze	26 (32)	(3)

* Lower Respiratory

⁺Two or More Chest Illnesses with Lower Respiratory Symptoms

Table 7. Frequency of Acute Symptoms Among Nonsmoking Teachers and Administrative Staff (n = 147)

	Number <u>Responding</u>	Number (% of 147) <u>Positive</u>
<u>Group 1: Positive if Occurring More than Once per Week</u>		
Eye Irritation	102	59 (40)
Runny/Stuffy Nose	111	54 (37)
Sneezing	106	46 (31)
Chest Tightness	59	16 (11)
Shortness of Breath	61	22 (15)
Nausea	68	11 (7)
Headache	124	50 (34)
Sleepiness	116	73 (50)
Difficulty Concentrating	74	33 (22)
Tense/Nervous	87	37 (25)
<u>Group 2: Positive if Occurring At Least Once per Month</u>		
Sore Throat	98	61 (41)
Hoarseness	89	58 (39)
Rash, Dry Skin	75	52 (35)

Table 8. Proportion of Nonsmoking Faculty and Staff Reporting That Symptoms Occur More Frequently or at Least as Frequently at School As Compared to Home for those Reporting a High Frequency of Symptoms

		At least as Frequently <u>At School</u> <u>No. (%)</u>	More Frequently <u>At School</u> <u>No. (%)</u>
<u>Group 1</u>			
Eye Irritation	(n=59)	58 (98)	48 (81)
Runny/Stuffy Nose	(n=54)	52 (96)	37 (69)
Sneezing	(n=46)	45 (98)	22 (48)
Chest Tightness	(n=16)	15 (94)	13 (81)
Shortness Breath	(n=22)	20 (91)	14 (64)
Nausea	(n=11)	11 (100)	10 (91)
Headache	(n=50)	49 (98)	36 (72)
Sleepiness	(n=73)	72 (99)	57 (78)
Concentration	(n=33)	33 (100)	19 (58)
Tense/Nervous	(n=37)	37 (100)	24 (65)
<u>Group 2</u>			
Sore Throat	(n=61)	61 (100)	42 (69)
Hoarseness	(n=58)	58 (100)	49 (84)
Rash, Dry Skin	(n=52)	52 (100)	27 (52)

Table 9. Frequency of Acute Symptoms Among Nonsmoking Other Staff (n = 81)

	Number <u>Responding</u>	Number (% of 81) <u>Positive</u>
<u>Group 1: Positive if Occurring More than Once per Week</u>		
Eye Irritation	56	36 (44)
Runny/Stuffy Nose	61	28 (35)
Sneezing	52	25 (31)
Chest Tightness	30	2 (2)
Shortness of Breath	28	3 (4)
Nausea	21	2 (2)
Headache	59	23 (28)
Sleepiness	58	40 (49)
Difficulty Concentrating	38	19 (23)
Tense/Nervous	39	16 (20)
<u>Group 2: Positive if Occurring At Least Once per Month</u>		
Sore Throat	49	24 (30)
Hoarseness	41	19 (23)
Rash, Dry Skin	37	27 (33)

Table 10. Proportion of Nonsmoking Other Staff Reporting That Symptoms Occur More Frequently or at Least as Frequently at School As Compared to Home for Those Reporting a High Frequency of Symptoms

		At least as Frequently <u>At School</u> <u>No. (%)</u>	More Frequently <u>At School</u> <u>No. (%)</u>
<u>Group 1</u>			
Eye Irritation	(n=36)	36 (100)	29 (81)
Runny/Stuffy Nose	(n=28)	28 (100)	20 (71)
Sneezing	(n=25)	25 (100)	10 (40)
Chest Tightness	(n= 2)	2 (100)	2 (100)
Shortness Breath	(n= 3)	3 (100)	2 (67)
Nausea	(n= 2)	2 (100)	2 (100)
Headache	(n=23)	23 (100)	21 (91)
Sleepiness	(n=40)	39 (98)	34 (85)
Concentration	(n=19)	19 (100)	11 (58)
Tense/Nervous	(n=16)	16 (100)	10 (63)
<u>Group 2</u>			
Sore Throat	(n=24)	24 (100)	17 (71)
Hoarseness	(n=19)	19 (100)	16 (84)
Rash, Dry Skin	(n=27)	27 (100)	13 (48)

THE ASSESSMENT OF AIR QUALITY AND VENTILATION SYSTEMS
AT CAMBRIDGE RINDGE & LATIN SCHOOL COMPLEX, CAMBRIDGE,
MASSACHUSETTS

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January 1990

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1.0 Executive Summary

This report details the visual inspection, ventilation survey and environmental monitoring of selected areas of the Cambridge Rindge and Latin School Facility (CRLS) located at 459 Broadway, Cambridge, Massachusetts. This work was carried out strictly as an industrial hygiene survey to determine the effectiveness of the existing ventilation system and to measure certain contaminants that may be associated with complaints noted by the building occupants. Complaint questionnaires were administered to occupants of the building to qualitatively determine the type and distribution of complaints and their prevalence at this point in time. The scope of this contract did not include a health survey. Health related surveys were administered to students and staff under separate contracts to John Snow Research and Training Institute, Inc., and Professor J. Ware of the Harvard School of Public Health.

The results obtained in this study indicate that there are several factors that exacerbate, and in some cases probably cause, the complaints of nausea, headache and lethargy noted by the building occupants. Specific findings detailed in this report are as follows:

OBSERVATION:

1. Inadequate amounts of outside air are being delivered to the occupants of many areas of CRLS. This results from operational inadequacies such as blocked reheat coils, blocked duct work, etc., closed and/or inoperative outside air dampers etc. (Section 4.0).

RECOMMENDATION:

This is a potentially serious problem that should be addressed in light of the impact that it has on the overall environmental control system of the building. This would involve cleaning (by professionals) of the duct work, air intakes, coil surfaces, etc. to eliminate blockage. Also all supply fans must be adjusted to deliver specified air volumes and outside air dampers must be properly adjusted and fully operational.

OBSERVATION:

2. The building HVAC system is in general disrepair. This is true of both the rooftop units serving the central core areas and the unit ventilators servicing the perimeter rooms. Filters have not been changed with the required frequency necessary, thereby reducing the effective ventilation to the space and contributing to the build-up of particles in the duct work. Other aspects of routine maintenance have been neglected, thereby resulting in a reduced efficiency of HVAC operation.

RECOMMENDATION:

Repair systems to achieve design specification and upgrade where necessary to achieve compliance with ASHRAE 62-1989. Repair and replace HVAC components where necessary to eliminate the "emergency" response as the norm, and concentrate on routine preventive maintenance.

OBSERVATION

3. Exhaust fans are either not operating or operating at efficiencies of generally less than 20% of design. Therefore, classrooms are pressurized with respect to the hallways. Odor and contaminants are not effectively ventilated from the building,

except through exfiltration around doors, etc. and will tend to increase the perception of the air in the building as stale or malodorous (Section 5.5).

RECOMMENDATION:

It is necessary to improve efficiency of exhaust fans and bring them back to design setting. This may involve replacing belts, oiling/greasing bearings or looking at exhaust control systems in the duct work to be sure they are working properly.

OBSERVATION:

4. The outside air dampers tend to go to a minimum setting or close completely when the temperature drops below 35°F. This can severely limit the amount of outside air being delivered to the space and may be inadequate to meet occupant requirements.

RECOMMENDATION:

Change existing circulating water solution in the heating system to contain 50% ethylene glycol. This will minimize the possibility of freeze-ups on the systems, and permit the establishment of a greater minimum outside air (OA) setting. This will also involve adjusting controls.

OBSERVATION:

5. The greenhouse located on the third floor of the Rindge building has been a source of concern for many of the occupants of CRLS. Although the advantages of having a greenhouse on-site are obvious, the original design and subsequent modifications render it difficult to meet and maintain the comfort and air quality requirements of the occupants of adjoining rooms. The thermal load that results from the large glass area of the greenhouse has caused extreme discomfort to occupants in the immediate area. Odors emanating from potting soil and materials used in the greenhouse area have emanated throughout rooms and hallways on the third floor of the Rindge building. The original design, in which vents are open at the top of the greenhouse, is inadequate for ventilation and has become an area for pigeons to enter and roost, resulting in debris such as pigeon droppings and feathers, etc. being found throughout the area.

RECOMMENDATION:

Based on our observation and discussion with people in the building it appears appropriate that the greenhouse should be disassembled. This would alleviate excess heat build-up and eliminate nesting places for the pigeons. Short of this, an increase in the ventilation rate to the greenhouse must be made. This would involve roof mounted vent fans that would be activated to maintain a constant air temperature in the space. Screens would have to be installed in all operable roof vents to eliminate the entry of pigeons into the greenhouse. Sun screens would be required on the exterior walls of the greenhouse to minimize radiant heat build-up. Additionally, special precautions would be needed to insure that no products are used in the greenhouse that would effect the comfort or health of occupants in the remainder of the building. This would require one individual to be accountable for all materials used and stored in the greenhouse.

OBSERVATION:

6. Certain areas on the roof as indicated in the report have ponds of standing water. Some of these are from roof drains that are blocked or have been made smaller during roof renovations (Section 5.2).

RECOMMENDATION:

Appropriate action should be taken to drain all roof ponds, many of which are near the air intakes for rooftop units. All drains should be cleaned and strainers installed to catch debris.

OBSERVATION:

7. Throughout the building, numerous thermal comfort complaints have been noted. These are areas of hot and cold complaints that many times have no seasonal foundation. This can generally be attributed to either malfunctioning of the HVAC pneumatic control system or inappropriate thermostat location, such that the thermostat fails to respond to changes in thermal conditions occurring in the occupied space. This is exacerbated by people's actual physical sensations when moving between areas that are and are not air conditioned. During the Fall and Spring seasons, the differences between spaces that are and are not air conditioned can be as much as 20°F. Temperature swings of this magnitude are undoubtedly quite noticeable and can be irritating.

RECOMMENDATION:

The location of the thermostats, their set-points, and calibrations should be addressed to insure that appropriate ASHRAE thermal comfort guidelines will be met. Some re-thinking of temperature set-points with respect to thermal conditions between conditioned and non-conditioned spaces must be made to minimize temperature discontinuities.

OBSERVATION:

8. Tests conducted to verify the operation of the HVAC pneumatic control system revealed that the system has been by and large neglected. In some areas of the building, it was impossible to obtain sufficient control air pressure to attain proper operation of the unit ventilators. This lack of pressure is generally caused by excessive leaks through thermostats, tubing, etc. Inadequate control pressure can cause the unit ventilator to close its outdoor air damper and open its hot water valve, resulting in overheated rooms. It was also observed that the compressor which provides pneumatic control air was poorly maintained.

RECOMMENDATION:

The pneumatic system used to control HVAC systems must be reconditioned. First, an operational inspection conducted by a control systems contractor is needed.

Second, a log of thermal discomfort and facility manager response must be maintained. This will provide guidance as to which systems need additional inspection/repairs.

OBSERVATION:

9. Many areas have been found to be deficient in outside air flow, or their control system appears to be inadequate to respond to changes in ambient conditions.

RECOMMENDATION:

Increase the amount of outside air by re-positioning the dampers to insure that the control system is operating in the manner expected. This may require additional upgrades of certain re-heat coils to insure adequate tempering of air before delivery to the occupied spaces.

OBSERVATION:

10. Some fans in the rooftop units are undersized relative to original design specifications for these units. Therefore, these fans do not deliver the flows required (Section 5.2).

RECOMMENDATION:

- Upgrade RTU#1, change existing 7 1/2 HP supply fan motor to 10 HP.
- Upgrade RTU#5, change existing 5 HP supply fan motor to 7 1/2 HP.
- Upgrade RTU#8, change existing 7 1/2 HP supply fan motor to 10 HP.

OBSERVATION:

11. Specific code violations have been observed regarding vent stacks and nearby fresh air intakes (Section 5.3). These involve not only plumbing vent stacks but also the position of exhaust fans relative to fresh air intakes.

RECOMMENDATION:

Resolve code violations as detailed in Section 5.3. Be sure they are consistent with the building code of the Commonwealth of Massachusetts. Plumbing stacks and vents are to be at minimum, 10 feet from air intakes.

OBSERVATION:

12. In many rooms there is poor distribution of supply air from the existing mechanical system. This is due either to the location of the unit ventilators, which are either too high above the occupied space or near an obstruction of air flow such as structural beams or light fixtures. In some rooms the unit ventilators are significantly undersized with respect to ASHRAE 62-1989 requirements.

RECOMMENDATION:

In rooms specified in Section 5.4, add ductwork extensions to increase effective ventilation to the occupied space. Adjust deflectors on all unit ventilators so that they direct air to the occupied space without causing excessive drafts. In the rooms that have unit ventilators that are either at or below the maximum flow for achieving ASHRAE 62-1989, supplementary window fans should be installed. These would be installed in pairs in the room (one supply and one exhaust), and would be controllable by room occupants.

OBSERVATION:

13. Tracer gas studies show that many rooms do not have adequate outside air supply. The goal of 15 cfm of outside air per occupant throughout all seasons cannot be achieved in many of these rooms.

RECOMMENDATION:

As stated earlier, the volume of outside air must be increased by either increasing the minimum setting for outside air dampers and/or upgrading the supply fan motor.

OBSERVATION:

14. Tracer gas studies show the potential for cross contamination from one area in the building to another. Hence, there is a high potential for contaminants to migrate to more sensitive areas. These "sensitive receptor" and source areas include:

- Health Center from machine shop
- Day Care Center from metal fabrication shop
- R133 from metal fabrication shop
- Men's locker room (War Memorial) from parking garage
- Field house (War Memorial) from parking garage

RECOMMENDATION:

All areas should be returned to original design specification. Insure that all installed systems are working properly. Upgrade specialized exhaust to effectively control sources, minimize system bypass and maintain proper differential pressure relationships. After engineering controls are functioning recheck these areas to identify other routes of entry or lack of efficiency in the specialized exhaust systems.

2.0 Introduction

This report summarizes the result of an industrial hygiene and engineering study designed to obtain information on building related factors that could influence the air quality in the Cambridge Rindge & Latin School complex located at 459 Broadway, Cambridge, Massachusetts. As such it incorporates the visual inspection of the premises and the major components of the HVAC system, ventilation rate determination by tracer gas measurements and environmental sampling for selected volatile organic compounds, airborne particulate matter, airborne fiberglass analysis, and microbiological contaminants in selected areas. The on-site testing was directed by John F. McCarthy, Sc.D., C.I.H. and Jerry F. Ludwig, Ph.D. of Environmental Health and Engineering, Inc. On-site arrangements were made by Mr. Paul Mahoney, Facilities Coordinator, Cambridge School Department. Several meetings were held with school administrators and occupants of the building to identify specific areas of interest in the facility. Additional input was secured through self administered complaint forms that are available to occupants of the building which were collected and analyzed by Environmental Health and Engineering.

This study was designed to assess current conditions in the building. Although information was obtained from occupants regarding previous symptoms, no attempt was made to reconstruct the history of possible previous exposures. A parallel study to evaluate health related sources is being carried out by the Harvard School of Public Health under the direction of Dr. James Ware, Dr. Frank Speizer and Dr. Diane Gold. Additional analysis assessing cancer rates at CRLS was carried out by Dr. David Ozonoff of the Boston University School of Public Health and Dr. Richard Clapp, of John Snow Research and Training Institute, Inc.

Please note that the studies and results presented in this report are subject to the limitations presented in Appendix A.

3.0 Historical Background and Current Concerns

In 1973, Rindge Technical School and the Cambridge High and Latin School merged to become the Cambridge Rindge and Latin School. Over the next eight years, major additions and renovations to the physical plant occurred. The Rindge Technical School building, which was built around 1920, was remodeled and a Media Wing was added to the building. The War Memorial, which houses a swimming pool and locker rooms and was constructed in the late 1940's, was renovated. A Field House, Arts Building, and Parking Garage were constructed on the complex.

Students and staff began moving back into the remodeled Rindge building in 1979, while renovations were still proceeding within the building. The School was formally completed in 1981.

Occupancy is currently approximately 2600 people, with about 2300 students and 300 faculty and staff members. Since this is a classroom/office complex, the occupancy level can vary dramatically based on the time of year as well as the time of day.

Complaints of stuffiness and odors were reported almost immediately after the buildings were re-occupied. Symptoms including headaches, fatigue, drowsiness, nausea, dizziness, eye irritation and upper respiratory irritation were reported with unusual frequency. A maintenance log was started by the School in 1983 to document HVAC system failures and complaints. Maintained through 1989, the log lists frequent ventilation system failures, as well as occupant complaints of odors, uncomfortable temperatures, and stuffiness.

An investigation was undertaken by the Cambridge School Department in 1984 to assess the nature and extent of the air quality problem at the School. The investigation consisted of studies performed by Kevin McManus of the National Institute of Occupational Safety and Health (NIOSH); Richard D'Aquanni of the Applied Resources Group, Inc.; Michael Burke of Johnson Controls; and Dr. Francis Berlandi of Touchstone Environmental Consultants.

The conclusion of the NIOSH study, which was supported by the findings of the other studies, was that symptoms reported were due mainly to inadequate fresh air. According to the NIOSH study, the design, operation and inadequate and irregular maintenance of the HVAC system were not conducive to a ventilation rate or temperature modulation that could provide comfort to a reasonable fraction of the buildings' occupants.

In the spring of 1985, a thorough analysis of the Cambridge Rindge and Latin School HVAC system was conducted by the Cambridge School Department with the assistance of Mr. Joseph Nahas, a consulting engineer. Numerous recommendations regarding improvements to the School's ventilation system were made, with many implemented over the next several years.

The health complaints reported at Cambridge Rindge and Latin School are typical of those reported in buildings with inadequate ventilation. Several questionnaires have been distributed to the staff and students of the School to document the health complaints reported. 2200 questionnaire responses were collected by Dr. Berlandi in early 1985. Fatigue and headaches were reported by about 60% of the respondents, and dizziness and respiratory complaints by 30%.

The symptoms noted above had persisted through the spring of 1989. Concern of the occupants was heightened when the death of an individual at the School, believed to have

occurred from brain cancer, was followed by the report that a second individual at the School had the preliminary diagnosis of brain cancer.

This prompted the initiation of a three part program to (1) thoroughly evaluate the environmental conditions at Cambridge Rindge and Latin and recommend corrective action when needed, (2) assess whether the faculty and staff had experienced unusual rates or types of cancer, and (3) survey through the use of questionnaires the illness and symptom experience of the faculty and staff.

This report comprises the evaluation of the environmental conditions at Cambridge Rindge and Latin School.

4.0 Ventilation System General Observations and Recommendations for Corrective Action

The physical plant of the Cambridge Rindge & Latin School consists of a complex of buildings which include the Rindge Building, Arts Building, Field House, War Memorial, and Parking Garage. The studies reported here concentrated on the Rindge and Arts Buildings since the student population spends most of their time there although observations were also made in the Field House, War Memorial, and Parking Garage. These buildings are serviced by a combination of rooftop units and unit ventilators. The Rindge and Arts Buildings enclose in excess of 250,000 square feet of space, containing classrooms, laboratories, offices, and shops.

The heating, ventilation and air-conditioning (HVAC) requirements of the buildings are accomplished with a distributed system which consists of 20 direct expansion rooftop air handlers, which service interior spaces of the building, and unit ventilators, which ventilate and heat perimeter spaces in these buildings. The HVAC system as designed is capable of cooling only interior spaces of the building. The roof-top units condition multiple spaces by first cooling to a set supply air temperature the air in the common supply duct, and then re-heating the air supplied to individual spaces based on the thermal requirements of these spaces. The roof-top units are equipped with an economizer cycle which, when outdoor air thermal conditions are moderate, supplies the maximum amount of outdoor air. During other conditions, the units modulate their outdoor air dampers so that the units' supply air temperature is maintained at its set-point with the minimum amount of compressor operation.

On-site evaluation of the Cambridge Rindge & Latin School began on May 19, 1989. This initial evaluation consisted of walk-through observations of the major components of the HVAC systems, and a review of the mechanical plans from the most recent renovation of the building. After this initial evaluation, testing of the HVAC System commenced. This testing consisted of the observations and measurement of the following parameters:

1. Measurement of supply and exhaust air flows for the classroom, office and shop spaces serviced by unit ventilators, and for rooftop units in the Rindge and Arts Buildings.
2. Visual observations of the condition of all rooftop units. Observations made for each unit included the cleanliness of all heat transfer coils, cleanliness of the cooling coil drain-pan, condition and tension of all drive belts, condition of the air filters, and operation of outdoor and return air dampers and their associated pneumatic controls.
3. Measurement of fan speeds for a subset of exhaust fans.

The following is a list of our recommendations based on these observations and measurements:

1. With few exceptions, the filters in both the roof tops units (RTUs) and the unit ventilators (UVs) in the classroom are in need of replacement. It's apparent that the filters are not changed often enough. We recommend that replacement filters be approved by EHE to assure the quality of the product. We also recommend that all filters on RTUs be changed at least four times a year, and on UVs at least three times a year. To minimize time and costs of this task, it would be preferable if all filters were changed at one time, rather than staggering the change schedule, as is

currently done. Furthermore, when the filters are changed a sticker listing the date of change should be affixed to the ventilator in a visually accessible location.

2. All of the coils in both the RTUs and UVs should be thoroughly cleaned. This should be done using compressed air and a HEPA vacuum cleaner. The compressed air should be blown from the downstream side of the coil to the upstream side. On the upstream side, a HEPA vacuum cleaner should be used to collect the dirt blown from the coils by the compressed air. Alternatively, this could be done using a duct cleaning contractor who has been approved by EHE to insure the safety of any and all chemicals used. While the RTUs and UV coils are being cleaned, the same cleaning should apply to all of the reachable ductwork in the cases of the RTUs and UVs.
3. All condensate drain pans on the RTUs should be thoroughly cleaned. This should be done using steam and water. Also, all drain pans should be checked to see that they are properly draining. All drain pans should be adjusted so that no areas of potential water collection exist (i.e., low spots are available for water to fill that are not immediately drained).
4. In both the RTUs and UVs, attention should be paid to the filters and spacers used to assure that there is no bypass for air to leak around the filters.
5. In all of the RTUs, the belts should be adjusted so that they have the proper running tension. It should be common practice that whenever belts are changed, they are first tensioned, run for a few days, and then re-tensioned to take up slack that results as the belt is "broken-in".
6. Even though efforts have been made to assure that all areas are operating with the maximum amount of outdoor air, it was evident from our observations that this operating condition is not finding its way into practice. For each RTU, a thorough check needs to be conducted as to the "sequence of operation" for controlling the outdoor air damper. It should be confirmed that this sequence is functioning properly and that the RTU is currently being run following the proper sequence.
7. In most areas of the building, our measurements of supply and exhaust flow rates have revealed that flows are far less than the original design requirement. This may be partially due to the dirt loading of the system's coils, filters, and ductwork. A thorough cleaning of these parts of the system should be helpful in restoring the original design performance (assuming it ever did achieve this performance), but the system may still need re-balancing after it has been cleaned.
8. At least a half-dozen RTUs have leaks in the freon loops. This was apparent by the number of empty freon cans on the roof, and the number of RTUs with permanently attached charging manifolds and freon containers. Efforts should be made to stop all system leaks. This would allow the maintenance contractor to change the focus of the maintenance activity from handling "problem" calls to performing routine maintenance (filter changing, equipment servicing, coil cleaning, and thermostat calibration).
9. In some of the UVs, no pneumatic air is being supplied to control the unit. This has the effect of allowing no outdoor air into the unit (the outdoor air damper is normally closed), and requiring the UV to permanently supply hot water to the coil (the coil valve is normally open). These pneumatic air lines need to be repaired. If this failure was due to water and/or oil in the pneumatic air lines, and this has

caused other control parts to fail, then all affected parts will have to be replaced, and/or re-calibrated.

10. Effort should be made to clean all diffusers and joints in the ductwork that are soiled by dust streaks. While this problem may be only visual, it reminds the occupants that this building has in the past suffered from "sick building syndrome".

5.0 Results of On-Site Evaluations and Recommendations for Corrective Action

5.1 Testing of Pneumatic Controls

During the week of 14 August 1989 an independent temperature control contractor was engaged to determine the actual operation of the classroom unit ventilators and the rooftop units control systems.

The condition of the control systems of a representative sample of unit ventilators was evaluated using a control system simulation test. This simulation technique involved artificially applying control signals, and monitoring the response of the units. In this way, the performance of the unit ventilators to various environmental conditions was evaluated. Especially important in these tests was the response of the outdoor/return air damper to the outdoor air temperature signal.

A representative sample of fourteen (14) unit ventilators were tested for operation of all control functions. Of particular interest was the response of the outdoor/return air damper, at various simulated outdoor air temperatures. The units tested were selected in various areas of the buildings so that a representative sample of units in different locations would be evaluated. All of the units tested were designed to be controlled in exactly the same manner.

The following outdoor air damper operation was observed for all units at the following simulated outside air temperatures:

- At 55°Fahrenheit the outside air damper was open 50%.
- At 40°Fahrenheit the outside air damper was open 20%.
- At 35°Fahrenheit the outside air damper was closed.

This sequence of control severely restricts the amount of outside air to the classrooms for ventilation. At 35°F and below, no outside air is delivered to the classrooms. The current ASHRAE Standard (ASHRAE, 62-1989) is 15 cfm (cubic feet per minute) per person of fresh outside air in the classroom at all times regardless of outside air temperature. Based on a review of engineering weather data we have calculated that as the units are currently set to operate no outside air would be provided to spaces conditioned by unit ventilators for approximately 570 hours (70 days) of the normal academic year.

The unit ventilator exhaust systems are controlled by a signal from the unit ventilator to modulate a damper in the exhaust duct work to regulate exhaust flow. As currently installed, (assuming proper operation) the exhaust damper will close completely when the outdoor air temperature is 10°F. This limits the amount of air exhausted from classrooms and allows odors, etc., to build within the room.

During these tests, small air leaks in several of the unit ventilators were noted. It appears that the original pneumatic tubing supplied with the unit ventilators has deteriorated to the point at which it should be replaced. At some unit ventilator locations, the proper pneumatic supply pressure was not available. The cause of this is likely due to leaks throughout the system, which tend to bleed more control air than is possible to supply through the system. The lack of the proper pneumatic supply air pressure was especially apparent at unit ventilator locations farthest from the pneumatic control system compressed air supply, which is located in the boiler room.

A similar procedure was used to evaluate the control systems of the rooftop units (RTUs). This simulation showed that when the outdoor air temperature is 35°F, the outside air dampers close to a minimum position. Between the temperatures of 35 and 75°F, the outdoor air dampers modulate to maintain the air temperature discharged from the RTU at 55°F. Above 75°F, the outdoor air damper returns to a minimum position.

The minimum outside air requirement for each RTU is different. The minimum damper position for each RTU should be determined based on objective measurements of either an occupant generated pollutant such as CO₂, or by use of a tracer gas such as SF₆ that has been released into the system. It is expected that the minimum outdoor air damper position for most RTUs will need to be increased. There are many re-heat coils in the systems which will not be of adequate size to provide the necessary BTU requirements of the colder air being delivered. These are being listed and arrangements made for their upgrading.

The condition of the compressed air system in the boiler room was observed to be lacking in service and attention. The compressed air filters are in need of changing and the two air filters on the intakes of the air compressors are in very bad condition. The air filters on the compressors should be replaced immediately.

5.2 Deviations from Design Specifications

During the inspections of the rooftop units (RTUs), it was discovered that some of the fans installed in the unit were undersized relative to the design specifications for these units. The net result of these deviations from the design specifications is that the units affected will not be capable of delivering the flow rates originally planned by the building designer. Therefore the following corrective work is necessary to bring the affected units back to original design specifications and increase the airflow of the units involved.

- RTU #1 change existing 7 1/2 H.P. supply fan motor to 10 H.P.
- RTU #5 change existing 5 H.P. supply fan motor to 7 1/2 H.P.
- RTU #8 change existing 7 1/2 H.P. supply fan motor to 10 H.P.

These changes will bring the RTU's to the original design specifications. All RTUs require new belts and those with two (2) or more belts must be of matched sets. Bearings must be oiled or greased.

5.3 Code Violations

The Building Code of the Commonwealth of Massachusetts requires plumbing stacks of vents to be a minimum of 10 feet from air intakes. It is also good practice to keep exhaust stacks or discharge from exhaust fans at a distance of twenty (20) feet from air intakes or to discharge the exhaust at a greater velocity above air intakes.

The following is a list of the violations of code and good practice observed at the school:

- RTU #3 (4") vent stack needs to be extended 10 feet.
- RTU #12 (4") vent stack needs to be extended 5 feet.
- RTU #8 two (4") vent stacks needs to be extended 5 feet.
- RTU #4 (2") vent stack needs to be extended 5 feet.
- Two exhaust fans require extensions between RTU #13 and 15.
- Two exhaust fans require extensions between RTU #4 and 5.
- One exhaust fan requires extension at RTU #12.

- RTU #11 exhaust air discharge that was installed is discharging toward the fresh air intake needs to be removed and re-installed.
- There is always a pond of water at the fresh air intakes for RTU #16, RTU #17 and RTU #13. A solution will have to be designed to eliminate this constant problem.

Note: Most of the exhaust fans discharge down to the roof and cannot be extended and will therefore require new utility fans.

5.4 Supply Air Distribution

As part of our inspection and measurement of unit ventilators, an evaluation of air distribution was made, based on the dispersion of smoke from a Draeger Air Current Tube. During this evaluation, it was noticed that in many spaces serviced by unit ventilators, the air distribution was very poor, with large areas of the room receiving little or no air from the unit ventilator. In most of these spaces the reason for poor air distribution can be attributed to the location of the unit ventilator, which is high above the occupied space of the room or near an obstruction to air flow. In many situations, the addition of ductwork will provide the proper distribution of supply air into the occupied space.

The following is a list of rooms that require a distribution system of ductwork and grilles to provide a more uniform air flow to all areas of the classroom. It is important that proper air circulation is supplied at occupant level to provide effective ventilation for the dilution of CO₂ and odors, and to minimize the areas of poor circulation that were evident during the smoke test assessment.

ARTS BUILDING

Rooms A108, A109B: extend existing duct and provide four (4) way throw diffuser.

A110, A101, A217, A219, A202 (2 UV's), A316, A305, A302, and A301 (2 UV's):
Install ducts to extend existing duct and provide four (4) way throw diffuser.

RINDGE BUILDING

Rooms R513, R502, R501, R512, R503, R504, R510, R509, R507, R403, R410, R400, R421, R404, R417, R316, R317, R325, R330, R329, R328, R333, R245 and R241:
install ducts to extend existing duct and provide four (4) way throw diffuser.

We further suggest that the balance of the unit ventilators receive adjustments to the existing registers to improve the air distribution within the classrooms. This will require adjusting diffuser louvers to direct air to the sides of the diffuser face and down.

5.5 Exhaust Systems

All exhaust fans are in need of routine preventative maintenance which includes new belts, bearings being greased, and RPM being checked for compliance with original specifications. Some exhaust fans require significant repair to put them back into operation.

Our inspection of thirty two exhaust fans revealed the following:

EF7A needs bearing
EF10 not operating

- EF11 not operating
- EF22 not operating
- EF34 needs bearing
- EF2 bolts rusted could not open
- EF53 motor seized
- EF30 not operating
- EF55 not operating
- EF35 not operating

The thirty two (32) exhaust fans inspected all had belts which were completely dried out and ready to break.

From these inspections and air flow readings it was determined that the design specifications were not being delivered. The physical inspection revealed that filter maintenance was not adequate resulting in the additional task of inspecting the re-heat coils.

These recommendations were submitted to the Cambridge School Department and were immediately implemented. This work is currently being done after the school day ends and the completion date is expected by the end of December.

Bay State York has reported that all exhaust fan work has been completed and a list of the required information has been submitted to EHE.

The inspection of the adequacy of this work performed by Bay State York is being done by EHE personnel.

5.6 Laboratory Hoods

Several laboratory hoods were found to be functioning below an acceptable standard. Following repairs to the fans for all laboratory hoods, the face velocity of the hoods were measured. Listed below are the results of these measurements. In addition to the velocity measurement, a notice of satisfactory performance was attached to the sash of the hoods evaluated. The sash height was also marked on each hood such that the face velocity at the hood opening was no greater than 150 ft/min. Currently the American Conference of Governmental Industrial Hygienists recommend that face velocities be maintained between 100 and 150 ft/min at the face of the hood.

<u>ROOM #</u>	<u>VELOCITY¹</u>	<u>COMMENTS</u>
A202	160 ft/min	Right hood
A202	142 ft/min	Left hood
A203	148 ft/min	Left hood
A203	105 ft/min	Right hood
A204	136 ft/min	Right hood
A204	135 ft/min	Left hood
R305	221 ft/min	Single hood
R307	165 ft/min	Single hood

¹ Measured with sash height at 12 inches. Note, sash heights were subsequently marked with a sticker to indicate optimum operational position, i.e., a face velocity between 100 and 150 ft/min.

6.0 Summary of Tracer Testing Results

This section presents the results of Sulfur hexafluoride Tracer Tests performed at the Cambridge Rindge & Latin School. These tests were divided into two phases. One phase provided information to characterize the air exchange rate (AER) of selected rooms of the building. The second phase provided information regarding the possible transfer of pollutants from areas in which normal activities would be expected to yield higher pollutant concentrations (i.e., shops, parking garage, etc) to areas in which more traditional school activities are conducted (classrooms and offices).

6.1 Description of Tracer Testing Procedure

6.1.1 Air Exchange Measurements

To characterize the air exchange rate in selected rooms of the building, a test procedure based on the ASTM Standard Test Method for Determining Air Leakage Rate By Tracer Dilution (Designation: E741-83) was used. This test method entails introducing a small amount of tracer gas into a room or zone of interest, thoroughly mixing it, and measuring the rate of tracer decay. The tracer used for these tests was sulfur hexafluoride (SF_6). Sulfur hexafluoride is a non-flammable, non-toxic gas, which does not naturally occur in the environment. Sulfur hexafluoride is detectable in the parts per billion range with portable instruments.

At the start of each test session, each room sampled was pre-screened to assure that no interfering tracer sources were present in the space. After this was done, the tracer was injected into the test space and allowed to mix. Then samples of air from each space were collected in small tedlar bags filled using a squeeze bulb. The contents of these bags were then analyzed for the tracer gas, on-site, using a portable calibrated ITI, Model 505 SF_6 Detector Chromatograph. The tracer decay rates of several different rooms were measured simultaneously.

The underlying assumptions for tracer gas measurement of air exchange rate are those of perfect mixing in the room (or zone), and steady-state air flow. Mathematically, these assumptions lead to equation 6.1:

$$C(t) = C_0 \cdot e^{-I \cdot t} \quad (6.1)$$

where:

$C(t)$	=	tracer gas concentration at time t .
C_0	=	tracer gas concentration at time $t = 0$.
I	=	air exchange rate.
t	=	time.

In this equation, the loss rate of tracer gas concentration conforms to the exponential dilution law.

6.1.2 Inter-Zonal Pollutant Transfer

To quantify the possible transfer of pollutants between areas of expected high air pollution (parking garage, shop areas, etc.) and areas where the occurrence of these pollutants would be less tolerable, a series of tracer gas measurements were conducted. The tracer used for these tests was sulfur hexafluoride (SF_6).

For these experiments, after first screening all zones for interfering tracer response, a small amount of tracer was released and allowed to thoroughly mix in the zone from which the expected high pollutant concentration was to be simulated. Then samples of air from each space tested were collected in small tedlar bags filled using a squeeze bulb. The contents of these bags were then analyzed for the tracer gas on site using a portable calibrated ITI, Model 505 SF₆ Detector Chromatograph.

To analyze the resultant tracer response, a method similar to that used by Maldonado & Woods (1983) was used, which is detailed in equation 6.2:

$$E_i = \frac{\int_{t=0}^{t=t} C_i dt}{\int_{t=0}^{t=t} C_{ref} dt} \quad (6.2)$$

where:

- E_i = Relative exposure to pollutants that a person in the *i*th zone would experience for the same time period as a person in the reference zone.
- C_{ref} = Concentration of the tracer pollutant in the reference zone (i.e. the zone where the occurrence of the pollutant would be expected).
- C_i = Concentration of the tracer pollutant in the *i*th zone.

Equation 6.2, defines a relative exposure in the *i*th zone as the ratio of contaminant exposure that a person in the *i*th zone would have with respect to the reference (or polluted) zone. For purposes of these tests, two important assumptions were made: 1) the exposure periods were the same for persons in both zones, and 2) the response in the *i*th zone was due to tracer contamination only from the reference zone.

6.2 Location of Tracer Testing

Tracer test studies performed at Cambridge Rindge & Latin School consisted of 44 zones measured for tracer decay, and 19 zones measured for cross contamination from potentially polluted zones. Table 6-1 summarizes the 63 tracer tests performed, indicating the test reference number, date, time and type of test performed.

6.3 Results of Ventilation Rate Determination

Ventilation rates for locations in the building tested were determined by statistically fitting the tracer data obtained using the procedure described in Section 6.1.1. The statistical procedure used to calculate ventilation rates was the method of "Least Squares".

Table 6-2 presents the results of the tracer tests, along with other pertinent parameters for each of the rooms tested. Notice the range of outside air flow per occupant in cubic feet per minute per person (CFM/person). These values range from 2 CFM/person, to 116 CFM/person. Contrasting these measurements with the requirements of ASHRAE 62-1989, which specifies 15 CFM of

outdoor air per occupant of a classroom and the Commonwealth of Massachusetts State Building Code of 10 cfm of outdoor air/person in a school. These tests indicate that many of the spaces within the building did not have adequate amounts of outdoor air supplied during the time these tests were performed. Assuming that tests were both temporally and spatially representative of the conditions that existed in the building complex before air quality remediation steps were started, about 1/2 of the rooms in the building had insufficient amounts of outdoor air supplied to them to meet the ASHRAE 62-1989 standard when these rooms were filled to the maximum allowable class size for that room.

The intent of ASHRAE Standard 62-1989 is to specify minimum ventilation rates and indoor air quality that will be acceptable to human occupants and to avoid adverse health effects. ASHRAE Standard 62-1989 defines acceptable indoor air quality as "air in which there are no known contaminants at harmful concentration as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction." ASHRAE's recommended ventilation rate is based on the amount of outdoor air needed to supply sufficient oxygen, and control the concentration of CO₂ in the space such that the, CO₂ concentration does not exceed 1000 PPMv. For spaces used as classrooms/offices and laboratories, ASHRAE 62-1989 recommends 15 and 20 CFM/person respectively.

Spaces that do not meet the ASHRAE 62-1989 guidelines should not be automatically considered an area unsafe for occupancy. As such, ASHRAE guidelines recognize that comfort conditions should be maintained in the space. It is likely that spaces that do not meet the ASHRAE guidelines will have CO₂ concentrations in excess of 1000 PPMv, assuming maximum occupancy for a time period long enough to attain steady-state conditions. In spaces with CO₂ concentration above 1000 PPMv, some of the more sensitive occupants of the space may be expected to express dissatisfaction with the environment. Research has shown that in spaces with high CO₂ concentrations, occupants report feelings of thermal discomfort (warmth) sooner than when CO₂ concentrations are at normal levels (less than 1000 PPMv). Prolonged exposure to high CO₂ concentrations may result in other health effects including headaches, nausea, etc. These effects are not normally thought to occur until CO₂ concentrations reach about 7500 PPMv. The current OSHA standard for CO₂ concentrations in industrial settings is 10,000 PPMv.

Spaces with higher CO₂ concentrations may be expected to contain human odors that are offensive to persons upon their initial entrance to the space. Research has shown that as persons become acclimated to the space, (which usually takes about 15 minutes) their perception of human body odor diminishes.

In spaces which do not meet current ASHRAE Guidelines, remediation steps should be performed to achieve the goals of the standard. In many cases at CRLS, steps have been taken to achieve these results. These remediation steps include the cleaning of the coils, and installation of new air filters which will increase the performance of the ventilation systems, and the resetting of the outdoor air dampers so that these systems provide more outdoor air when operated at their minimum outdoor air settings under occupied conditions.

6.4 Cross Contamination Measurements

Cross contamination between selected locations in the building tested were determined using equation 6.2, and the procedure and assumptions described in paragraph 6.1.2. The numerator and denominator for this equation were determined by numerically integrating the response of the cross contaminated zone, relative to the numerically integrated response of the contaminated zone.

Table 6-2 Results of SF₆ Ventilation Rate Studies.

Location	Volume	RT#	OA AC/Hr Test	Max Occ ¹	CA CFM ²	OA CFM/ Occ	Measured Supply CFM ³	Measured % OA ⁴
A003	2,100	3	0.41 T-22	7	14	2	733	NA
Cafe (Mid)	49,656	8	1.44 T-13	375	1188	3	NA	NA
A010	13,500	3	0.28 T-26	19	64	3	450	14%
A009	13,800	3	0.45 T-24	29	104	4	390	27%
A008	13,800	3	0.51 T-23	25	116	5	440	26%
A001	31,813	3	0.19 T-25	20	101	5	1864	5%
A002	16,900	3	0.51 T-29	28	143	5	690	21%
A007	12,300	3	0.61 T-27	23	125	5	1000	12%
Cafe (Uppe	21,600	12	2.02 T-09	120	726	6	NA	NA
R230	10,075	UV	1.23 T-20	31	206	7	460	45%
A201	9,188	UV	1.47 T-19	32	225	7	440	51%
Cafe (Low)	78,168	8	2.04 T-11	375	2655	7	NA	NA
A000-Hall	57,669	3	0.23 T-30	30	224	7	NA	NA
R317	9,000	UV	2.58 T-04	49	387	8	540	72%
A317	9,425	6	1.34 T-03	24	211	9	420	50%
R244	15,250	UV	1.01 T-16	29	257	9	370	70%
A316	12,375	UV	1.14 T-01	26	236	9	500	47%
R302	4,359	13	1.42 T-62	11	103	9	520	20%
R333	9,200	UV	1.78 T-02	28	273	10	400	68%
R306/R307	17,456	13	1.41 T-57	35	410	12	2670	15%
R115	9,150	UV	1.64 T-14	21	250	12	400	63%
R126	25,737	HV-3	0.69 T-50	23	298	13	NA	NA
R207	13,500	13	1.43 T-58	22	323	15	1180	27%
R257	10,500	UV	1.18 T-21	13	206	16	580	35%
R207	13,500	13	1.62 T-18	22	364	17	1180	31%
R344	8,800	UV	2.09 T-05	18	307	17	540	57%
R205	17,034	13	1.37 T-61	21	389	19	1000	39%
R206/R205A	17,034	13	1.41 T-60	21	399	19	1450	28%
R304	14,219	13	1.37 T-64	17	325	19	820	40%
R305	16,625	13	1.39 T-63	20	384	19	1774	22%
R204	13,500	13	1.40 T-59	16	315	20	1730	18%
R109	26,625	17	2.26 T-46	45	1004	22	1240	81%
HLTH CTR	21,600	New Sy	1.26 T-12	15	453	30	NA	NA
A202	20,150	UV	2.25 T-15	25	755	30	590	128%
A004	23,600	3	0.55 T-28	7	216	31	690	31%
R253	8,963	9	3.45 T-17	15	515	34	760	68%
R123	43,500	HV-4	1.88 T-44	35	1361	39	6110	22%
R130 (Dayc	24,600	UV	1.46 T-08	15	600	40	620	97%
A309	15,019	UV	4.54 T-07	24	1136	47	650	175%
Main Offic	10,950	17	4.18 T-10	10	763	76	763	100%
R107	68,475	HV-5	2.77 T-49	34	3158	93	10340	31%
R310	4,125	6	6.03 T-06	4	415	104	795	52%
R131	47,700	HV-1	2.51 T-55	18	1994	111	3340	60%
R128	25,650	HV-2	2.70 T-51	10	1156	116	NA	NA

Notes:

1. Maximum occupancy based on data from Vice-Principal's Office.
2. CFM of fresh outdoor air, derived from tracer measurements as discussed in paragraph 6.1.1.
3. Measured Supply CFM, is the result of EHE's measurement of total supply air, (outdoor air plus recirculated air) from room diffuser(s) before remediation.
4. Measured % Outdoor air, is the result of the CFM of outdoor air divided by Measured Supply CFM, expressed as a percentage.
5. NA - Indicates information not available for this parameter.

Table 6-3 presents the results of the cross contamination measurements. For the cross contamination study in which rooms R126 & R107 were the reference zones, it appears that R126 (the machine shop) was a potentially more significant source of nuisance odors than R107 (the carpentry shop) for the areas tested. Of special note is the relative concentration of the Health Center with respect to R126 (the Machine Shop). These two areas are adjacent to each other, and until recently, the area that is now the Health Center was part of the Machine Shop. The results of these tests suggest that more vigilance should be paid to the possibility of persons in the Health Center being exposed to pollutants that are the result of activities conducted in the machine shop. It should be noted that during the period that these relative exposure tests were performed, the Heating & Ventilating unit (HV) in the machine shop was not yet operational. In approximately the middle of October, 1989, the machine shop HV was made operational. This may significantly affect the relationship of the cross contamination of pollutants from this zone to other zones of the building. Since the Health Center is directly adjacent to the Machine Shop, the effect of the operational status of this HV will probably be significant. This area will be retested to assess the impact of the HV unit.

Cross contamination was studied between R131 (Metal fabrication shop) and other areas of the first floor Rindge Building. Table 6-3 shows that Room R130 (Day Care Center), and R133 (Vice Principal's Office) could expect to have 9% and 21% (respectively) of the levels that were experienced in the metal fabrication area. These tests were performed with the doors and windows of the metal fabrication shop closed, as they would be during the winter.

Cross contamination was studied between the parking garage, and various locations in the Arts Building, Field House and War Memorial. These results (see Table 6-3) indicate that persons in the Men's Locker Room and Field House may be exposed to as much as 5% and 13% (respectively) of the contaminant levels that a person spending the same time period in the parking garage would experience. Part of this problem may be the result of the operation of the exhaust fans in the garage, and the location of the discharge from these units relative the air intake locations of the Roof top units servicing these zones. At this point there are not significant contaminant levels emanating from the parking garage (see Section 7.7). However, this cross contamination should be corrected to eliminate the potential for any future problems.

Table 6-3 Relative Inter-Zonal Pollutant Exposure Ratios.

Pollutant Transfer from	R107	R126
R133	2%	1%
Cafeteria	6%	3%
Cust. Off	2%	1%
Main Off	3%	2%
Health CTR	12%	6%

Pollutant Transfer From R131 (Metal Fabrication Shop).

Stairway	3%
Hallway T	5%
Day Care	9%
R133	21%

Pollutant Transfer From Parking Garage

A303	0%
A307	0%
A106	0%
A001	0%
War Memorial	1%
A204	1%
Stair Near A310	1%
Men's Locker Room	5%
Field House	13%

7.0 Environmental Measurements

7.1 Volatile Organic Compound Measurements

Measurements to determine the presence of volatile organic compounds (VOCs) were conducted in two ways at Cambridge Rindge & Latin School. The first used Tenax cartridges to collect air samples from several locations in the school buildings to determine the "typical" volatile organic compounds present in the indoor air. Analysis was carried out after thermal desorption from the Tenax cartridges utilizing gas chromatography/mass spectrometry (GC/MS). The second method used a Century meter OVA-128 flame ionization detector (FID) to measure the total organic compounds that were present. This instrument provides a real time output for the detection of "hot spots" that may exist in the building. This aids the targeting of specific sampling locations for chemical speciation studies.

7.1.1 Speciation of Volatile Organic Compounds (GC/MS)

Samples were collected from ten representative areas at CRLS with one additional outdoor sample to assess ambient background concentrations. Twenty liter samples were collected at 0.2 L/Min. on 24 August 1989. After collection, the Tenax cartridges were analyzed by Performance Analytical, Inc., of Canoga Park, CA, for twenty-five volatile organic compounds using GC/MS. These 25 VOCs appear on EPA's target list and have been detected in personal and indoor monitoring studies. A summary of their analytical procedure is provided in Appendix E-1. The results are presented in Table 7-1a through 7-1k. Table 7-1l is a listing of currently acceptable indoor air concentrations for these compounds. It should be noted that the VOC concentrations presented in Table 7-1a through Table 7-1k are given in parts per billion (PPB) while Table 7-1l is in parts per million (PPM).

Most of the compounds sampled for are below the quantitation limit of the analytical method and are reported as non-detected (ND). Those found in measurable quantities, are within the levels typical for office buildings and schools (Wallace et al, 1987). The one exception to this is the 1, 1, 1-trichlorethane that was found in the day care center. This compound is common and found in carpet glue, textured carpet, wallpaper glue, bleach, detergent aerosol propellant, rug/upholstery cleaners, etc. Repair work was going on in the area during sampling and it is believed that this is the likely source. Subsequent measurements with the OVA meter showed no elevated concentrations present.

The survey sampling plan was devised to sample most areas where the concentrations of vapors from volatile organic compounds might be elevated. These areas included the shop rooms, health center, custodian storage closets, administrative offices, copy center, mechanical and electrical rooms, and food preparation areas.

The areas sampled and the corresponding Tables are as follows:

Table	Area Sampled
7-1a	R133 (W. Mangan's Office)
7-1b	R110
7-1c	Student Service Center
7-1d	Health Center
7-1e	R130 (Day Care Center)
7-1f	Principal's Office (Main Office)
7-1g	R107 (Carpentry Shop)
7-1h	R126 (Machine Shop)

7-1i
7-1j
7-1k

A314 (Paint Shop)
R317 (Outside Greenhouse)
Ambient (Outside Main Door)

7.1.2 Total Volatile Organic Compounds (FID)

A Century 128-organic vapor analyzer (OVA) equipped with a flame ionization detector (FID) was used to sample for VOC's that may be present in the air. The instrument has a usable detection range from 1 part per million (ppm) to 1000ppm of organic vapor in air. The zero to 100 ppm range was used for this survey. Prior to the survey the instrument was zeroed using carbon filtered air and calibrated using a known concentration of 95 ppm methane gas in air. This standard is NBS traceable and the instrument response is found to be linear in this range. The instrument was checked with the calibration gas during the survey and at the conclusion to look for drift. The instrument was found to be extremely stable. Samples were collected on 14, 15 and 16 August 1989 and 6 and 7 November 1989.

These results are summarized in Table 7-1m. This data was collected in order to target any additional sampling for chemical speciation, and to see if VOCs collected in the aggregate may be presenting unacceptable total hydrocarbon exposures to occupants of the building. Prior work carried out by Molhave and his colleagues have indicated that the concentration of total VOC's present in a space may be an indicator of their potential to cause discomfort. (Molhave, 1986)

Certain specific areas where elevated levels of VOC's may be anticipated are described in more detail as follows:

Print shop (Arts building) - a room where practical instruction is given to students through hands on experience using the equipment found in a small, commercial print business. The shop contains a small fire proof cabinet which is not vented to the exterior of the building. This area was surveyed by slowly walking around the room (for approximately 10 minutes). During the general survey of the shop, the instrument did not indicate the presence of VOC's, however, the air at the top of the cabinet did indicate approximately 20 ppm VOC's present. This appears to be localized and not spread throughout the entire shop.

Storage Space for the Print Shop - This area was for the general storage of supplies such as paper, inks, and equipment cleaning materials. The instrument response for this room was zero. Where there were open cans of cleaning solvents the instrument response was 10 ppm. However, because of the low background level found in the rest of the room there appears to be a little spread of the solvent vapor into the general room circulation.

Sheet Metal Shop - During this inspection the sheet metal shop instructor was working in the shop, fabricating duct work using adhesive with a toluene based solvent system (GPA72 manufactured for AGN Industries, Canton, Massachusetts). The levels of VOC's in the shop ranged between 15 and 20 ppm with the door to the outside and stairwell opened. The stairwell had a concentration of 14 ppm. (Note: After leaving the shop the instrument was returned to outside the building and response to ambient air was zero).

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #1 Batch #1

PAI Sample ID: 8900399

Test Code: GC/MS EPA TO-1 (Mod.)
 Analyst: Chris Casteel
 Instrument ID: 4500A/Tekmar 5010
 Verified by: Michael Today

Matrix: Tenax
 Date Received: 08/28/89
 Date Analyzed: 09/01/89
 Volume Analyzed: 19.7 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	ND	0.25	ND	0.08
75-09-2	METHYLENE CHLORIDE	5.0	0.25	1.5	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	ND	0.25	ND	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	6.0	0.25	1.1	0.05
71-43-2	BENZENE	2.9	0.25	0.92	0.08
56-23-5	CARBON TETRACHLORIDE	0.32	0.25	0.05	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	7.6	0.25	1.4	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	19	0.25	4.9	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	4.0	0.25	0.60	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	1.1	0.25	0.26	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	0.27	0.25	0.06	0.06
1330-20-7	TOTAL XYLENES	7.9	0.25	1.8	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABLE 7-1a (W. MANGAN'S OFFICE R133)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #1 Batch #1

PAI Sample ID: 8900399

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/01/89

Volume Analyzed: 19.7 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
64-17-5	Ethanol	1.8	0.94
67-64-1	Acetone	12	4.9
67-63-0	Isopropyl alcohol	5.6	2.3
78-93-3	2-Butanone	10	3.4
	C ₈ -C ₁₅ Hydrocarbon Matrix	620	---

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #2 Batch #1

PAI Sample ID: 8900400

Test Code: GC/MS EPA TO-1 (Mod.)
 Analyst: Chris Casteel
 Instrument ID: 4500A/Tekmar 5010
 Verified by: Michael Taday

Matrix: Tenax
 Date Received: 08/28/89
 Date Analyzed: 09/02/89
 Volume Analyzed: 19.9 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	0.58	0.25	0.19	0.08
75-09-2	METHYLENE CHLORIDE	2.7	0.25	0.80	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	1.5	0.25	0.30	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	4.5	0.25	0.84	0.05
71-43-2	BENZENE	2.1	0.25	0.66	0.08
56-23-5	CARBON TETRACHLORIDE	0.27	0.25	0.04	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	4.2	0.25	0.79	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	9.8	0.25	2.6	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	3.5	0.25	0.53	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	0.88	0.25	0.20	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	ND	0.25	ND	0.06
1330-20-7	TOTAL XYLENES	6.2	0.25	1.4	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABLE 7-1b (ROOM R110)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #2 Batch #1

PAI Sample ID: 8900400

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax
Date Received: 08/28/89
Date Analyzed: 09/02/89
Volume Analyzed: 19.9 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
64-17-5	Ethanol	1.4	0.72
67-64-1	Acetone	12	4.9
67-63-0	Isopropyl alcohol	13	5.3
78-93-3	2-Butanone	3.9	1.3
	Trichlorotrifluoroethane	1000	---
	Carbon disulfide	4	---
	C ₈ -C ₁₅ Hydrocarbon Matrix	> 6200	---

TABLE 7-1c (STUDENT SERVICE CENTER)

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #3 Batch #1

PAI Sample ID: 8900401

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Tuday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/01/89

Volume Analyzed: 20.9 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	ND	0.25	ND	0.08
75-09-2	METHYLENE CHLORIDE	1.7	0.25	0.50	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	ND	0.25	ND	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	2.7	0.25	0.50	0.05
71-43-2	BENZENE	1.8	0.25	0.57	0.08
56-23-5	CARBON TETRACHLORIDE	0.36	0.25	0.06	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	3.4	0.25	0.64	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	7.8	0.25	2.1	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	3.1	0.25	0.47	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	0.33	0.25	0.08	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	ND	0.25	ND	0.06
1330-20-7	TOTAL XYLENES	3.8	0.25	0.87	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABLE 7-1c (STUDENT SERVICE CENTER)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #3 Batch #1

PAI Sample ID: 8900401

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Tuday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/01/89

Volume Analyzed: 20.9 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
64-17-5	Ethanol	5.3	2.8
67-64-1	Acetone	11	4.4
67-63-0	Isopropyl alcohol	2.6	1.1
78-93-3	2-Butanone	3.7	1.3
	Pentadiene	9	---
	C ₈ -C ₁₅ Hydrocarbon Matrix	> 3600	---

TABLE 7-1d (HEALTH CENTER, DESK)

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #4 Batch #1

PAI Sample ID: 8900402

Test Code: GC/MS EPA TO-1 (Mod.)
 Analyst: Chris Casteel
 Instrument ID: 4500A/Tekmar 5010
 Verified by: Michael Today

Matrix: Tenax
 Date Received: 08/28/89
 Date Analyzed: 09/01/89
 Volume Analyzed: 20.7 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	ND	0.25	ND	0.08
75-09-2	METHYLENE CHLORIDE	2.5	0.25	0.72	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	ND	0.25	ND	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	15	0.25	2.8	0.05
71-43-2	BENZENE	1.9	0.25	0.61	0.08
56-23-5	CARBON TETRACHLORIDE	0.27	0.25	0.04	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	32	0.25	6.1	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	13	0.25	3.4	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	3.8	0.25	0.57	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	1.6	0.25	0.36	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	0.31	0.25	0.07	0.06
1330-20-7	TOTAL XYLENES	11	0.25	2.5	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABLE 7-1d (HEALTH CENTER, DESK)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #4 Batch #1

PAI Sample ID: 8900402

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/01/89

Volume Analyzed: 20.7 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
64-17-5	Ethanol	2.4	1.3
67-64-1	Acetone	14	6.1
67-63-0	Isopropyl alcohol	> 500	> 200
78-93-3	2-Butanone	8.7	3.0
	C ₈ -C ₁₅ Hydrocarbon Matrix	110	---

TABLE 7-1e (DAY CARE CENTER, R130)

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #5 Batch #1

PAI Sample ID: 8900403

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Tuday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/02/89

Volume Analyzed: 21.7 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	ND	0.25	ND	0.08
75-09-2	METHYLENE CHLORIDE	2.0	0.25	0.59	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	0.56	0.25	0.12	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	> 300	0.25	> 58	0.05
71-43-2	BENZENE	1.4	0.25	0.45	0.08
56-23-5	CARBON TETRACHLORIDE	ND	0.25	ND	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	0.64	0.25	0.12	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	11	0.25	2.8	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	0.90	0.25	0.13	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	0.32	0.25	0.07	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	ND	0.25	ND	0.06
1330-20-7	TOTAL XYLENES	4.2	0.25	0.96	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABLE 7-1e (DAY CARE CENTER, R130)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #5 Batch #1

PAI Sample ID: 8900403

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/02/89

Volume Analyzed: 21.7 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
64-17-5	Ethanol	0.65	0.34
67-64-1	Acetone	6.0	2.5
67-63-0	Isopropyl alcohol	1.0	0.41
78-93-3	2-Butanone	8.8	3.0
123-91-1	1,4-Dioxane	12	3.2
	n-Butyl acetate	10	---
	C ₈ -C ₁₅ Hydrocarbon Matrix	63	---

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #6 Batch #1

PAI Sample ID: 8900404

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Tuday

Matrix: Tenax
Date Received: 08/28/89
Date Analyzed: 09/01/89
Volume Analyzed: 23.0 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	ND	0.25	ND	0.08
75-09-2	METHYLENE CHLORIDE	1.4	0.25	0.41	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	0.72	0.25	0.15	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	1.2	0.25	0.22	0.05
71-43-2	BENZENE	0.85	0.25	0.27	0.08
56-23-5	CARBON TETRACHLORIDE	ND	0.25	ND	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	0.82	0.25	0.15	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	5.3	0.25	1.4	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	0.80	0.25	0.12	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	ND	0.25	ND	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	ND	0.25	ND	0.06
1330-20-7	TOTAL XYLENES	2.1	0.25	0.48	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABLE 7-1f (PRINCIPAL'S OFFICE, MAIN OFFICE)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #6 Batch #1

PAI Sample ID: 8900404

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Tuday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/01/89

Volume Analyzed: 23.0 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
64-17-5	Ethanol	3.7	2.0
67-64-1	Acetone	6.5	2.8
67-63-0	Isopropyl alcohol	2.4	0.97
78-93-3	2-Butanone	2.7	0.92
	C ₈ -C ₁₅ Hydrocarbon Matrix	93	---

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #7 Batch #1

PAI Sample ID: 8900405

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax
Date Received: 08/28/89
Date Analyzed: 09/01/89
Volume Analyzed: 22.6 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	ND	0.25	ND	0.08
75-09-2	METHYLENE CHLORIDE	1.5	0.25	0.43	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	1.2	0.25	0.25	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	5.6	0.25	1.0	0.05
71-43-2	BENZENE	2.2	0.25	0.69	0.08
56-23-5	CARBON TETRACHLORIDE	ND	0.25	ND	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	TR 0.20	0.25	TR 0.04	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	16	0.25	4.2	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	0.64	0.25	0.09	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	1.02	0.25	0.24	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	ND	0.25	ND	0.06
1330-20-7	TOTAL XYLENES	8.9	0.25	2.1	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABLE 7-1g (R107, CAPRENTY SHOP)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #7 Batch #1

PAI Sample ID: 8900405

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Tuday

Matrix: Tenax
Date Received: 08/28/89
Date Analyzed: 09/01/89
Volume Analyzed: 22.6 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
64-17-5	Ethanol	15	8.0
67-64-1	Acetone	8.8	3.7
67-63-0	Isopropyl alcohol	4.0	1.6
78-93-3	2-Butanone	4.0	1.4
	C ₈ -C ₁₅ Hydrocarbon Matrix	310	---

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #8 Batch #1

PAI Sample ID: 8900406

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/02/89

Volume Analyzed: 20.5 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	ND	0.25	ND	0.08
75-09-2	METHYLENE CHLORIDE	1.3	0.25	0.36	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	1.2	0.25	0.25	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	6.4	0.25	1.2	0.05
71-43-2	BENZENE	1.9	0.25	0.60	0.08
56-23-5	CARBON TETRACHLORIDE	ND	0.25	ND	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	4.8	0.25	0.90	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	9.9	0.25	2.6	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	1.0	0.25	0.15	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	0.70	0.25	0.16	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	ND	0.25	ND	0.06
1330-20-7	TOTAL XYLENES	7.9	0.25	1.8	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABLE 7-1h (MACHINE SHOP, R126)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #8 Batch #1

PAI Sample ID: 8900406

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/02/89

Volume Analyzed: 20.5 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
64-17-5	Ethanol	1.1	0.57
67-64-1	Acetone	8.8	3.7
67-63-0	Isopropyl alcohol	> 100	> 40
78-93-3	2-Butanone	4.3	1.5
	C ₈ -C ₁₅ Hydrocarbon Matrix	85	---

TABLE 7-1i (PAINT SHOP, A314)

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #9 Batch #1

PAI Sample ID: 8900407

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax
Date Received: 08/28/89
Date Analyzed: 09/01/89
Volume Analyzed: 15.6 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	ND	0.25	ND	0.08
75-09-2	METHYLENE CHLORIDE	1.6	0.25	0.47	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	ND	0.25	ND	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	ND	0.25	ND	0.05
71-43-2	BENZENE	1.3	0.25	0.42	0.08
56-23-5	CARBON TETRACHLORIDE	TR 0.11	0.25	TR 0.02	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	ND	0.25	ND	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	180	0.25	48	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	TR 0.17	0.25	TR 0.02	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	TR 0.22	0.25	TR 0.05	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	ND	0.25	ND	0.06
1330-20-7	TOTAL XYLENES	4.5	0.25	1.0	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABLE 7-1i (PAINT SHOP, A314)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #9 Batch #1

PAI Sample ID: 8900407

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/01/89

Volume Analyzed: 15.6 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
67-64-1	Acetone	1.1	0.46
67-63-0	Isopropyl alcohol	2.6	1.1
78-93-3	2-Butanone	2.1	0.72
	Methylhexane	30	---
	Dimethylcyclopentane	30	---
	n-Heptane	200	---
	Methylcyclohexane	200	---
	Trimethylcyclopentane	20	---
	Dimethylhexane	7	---
	Methylheptane	30	---

TABEL 7-1j (R317, OUTSIDE GREENHOUSE)

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #10 Batch #1

PAI Sample ID: 8900408

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/02/89

Volume Analyzed: 22.6 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	ND	0.25	ND	0.08
75-09-2	METHYLENE CHLORIDE	0.85	0.25	0.25	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	ND	0.25	ND	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	14	0.25	2.7	0.05
71-43-2	BENZENE	1.3	0.25	0.41	0.08
56-23-5	CARBON TETRACHLORIDE	ND	0.25	ND	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	ND	0.25	ND	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	12	0.25	3.2	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	TR 0.09	0.25	TR 0.01	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	0.55	0.25	0.13	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	ND	0.25	ND	0.06
1330-20-7	TOTAL XYLENES	4.5	0.25	1.0	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABEL 7-1j (R317, OUTSIDE GREENHOUSE)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #10 Batch #1

PAI Sample ID: 8900408

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/02/89

Volume Analyzed: 22.6 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
64-17-5	Ethanol	8.4	4.5
67-64-1	Acetone	4.2	1.8
67-63-0	Isopropyl alcohol	3.3	1.4
78-93-3	2-Butanone	1.5	0.51
	C ₈ -C ₁₅ Hydrocarbon Matrix	190	---

TABLE 7-1k (OUTSIDE MAIN DOOR, AMBIENT)

RESULTS OF ANALYSIS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #11 Batch #1

PAI Sample ID: 8900409

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Today

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/01/89

Volume Analyzed: 17.5 L

CAS #	COMPOUND	RESULT (UG/M ³)	DETECTION LIMIT (UG/M ³)	RESULT (PPB)	DETECTION LIMIT (PPB)
75-35-4	1,1-DICHLOROETHENE	ND	0.25	ND	0.06
75-15-0	CARBON DISULFIDE	ND	0.25	ND	0.08
75-09-2	METHYLENE CHLORIDE	1.5	0.25	0.42	0.07
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	0.25	ND	0.06
75-34-3	1,1-DICHLOROETHANE	ND	0.25	ND	0.06
67-66-3	CHLOROFORM	ND	0.25	ND	0.05
107-06-2	1,2-DICHLOROETHANE	ND	0.25	ND	0.06
71-55-6	1,1,1-TRICHLOROETHANE	ND	0.25	ND	0.05
71-43-2	BENZENE	1.7	0.25	0.54	0.08
56-23-5	CARBON TETRACHLORIDE	TR 0.16	0.25	TR 0.03	0.04
78-87-5	1,2-DICHLOROPROPANE	ND	0.25	ND	0.05
79-01-6	TRICHLOROETHENE	ND	0.25	ND	0.05
75-27-4	BROMODICHLOROMETHANE	ND	0.25	ND	0.04
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
10061-02-6	TRANS-1,3-DICHLOROPROPENE	ND	0.25	ND	0.06
79-00-5	1,1,2-TRICHLOROETHANE	ND	0.25	ND	0.05
108-88-3	TOLUENE	6.1	0.25	1.6	0.07
124-48-1	DIBROMOCHLOROMETHANE	ND	0.25	ND	0.03
127-18-4	TETRACHLOROETHENE	TR 0.09	0.25	TR 0.01	0.04
108-90-7	CHLOROBENZENE	ND	0.25	ND	0.05
100-41-4	ETHYLBENZENE	TR 0.08	0.25	TR 0.02	0.06
75-25-2	BROMOFORM	ND	0.25	ND	0.02
100-42-5	STYRENE	ND	0.25	ND	0.06
1330-20-7	TOTAL XYLENES	3.5	0.25	0.80	0.06
79-34-5	1,1,2,2,-TETRACHLOROETHANE	ND	0.25	ND	0.04

ND = Not Detected

TABLE 7-1k (OUTSIDE MAIN DOOR, AMBIENT)

TENTATIVELY IDENTIFIED COMOUNDS

Client: Environmental Health & Engineering Inc.

Client Sample ID: Tenax Tube #11 Batch #1

PAI Sample ID: 8900409

Test Code: GC/MS EPA TO-1 (Mod.)

Analyst: Chris Casteel

Instrument ID: 4500A/Tekmar 5010

Verified by: Michael Taday

Matrix: Tenax

Date Received: 08/28/89

Date Analyzed: 09/01/89

Volume Analyzed: 17.5 L

CAS #	COMPOUND	RESULT (UG/M3)	RESULT (PPB)
67-64-1	Acetone	5.7	2.4
67-63-0	Isopropyl alcohol	2.6	1.1
78-93-3	2-Butanone	1.4	0.49

TABLE 7-11. CURRENT ACCEPTABLE LEVELS FOR COMPOUNDS
MEASURED (1,3)

CAS Number	Target Compound	Common Synonym	TWA(2)		TWA/10(3)	
			ppm	mg/m ³	ppm	mg/m ³
67-64-1	Acetone		750	1780	75	178
75-35-4	1,1-Dichloroethene	Vinylidene Chloride	5	20	0.5	2
75-15-0	Carbon Disulfide		10	30	1	3
75-09-2	Methylene Chloride		50	175	5	17.5
75-34-3	1,1-Dichloroethane		100	400	10	40
78-93-3	2-Butanone	Methyl Ethyl Ketone	25	120	2.5	12
67-66-3	Chloroform	Trichloromethane	2	9.8	0.2	1.0
107-06-2	1,2-Dichloroethane	Ethylene Dichloride	1	4	0.1	0.4
71-55-6	1,1,1-Trichloroethane	Methyl Chloroform	350	1900	35	190
71-43-2	Benzene		1	3(4)	0.1	0.3
56-23-5	Carbon Tetrachloride		2	12.6	0.2	1.3
78-87-5	1,2-Dichloropropane	Propylene Dichloride	75	350	7.5	35
79-01-6	Trichloroethene	Trichloroethylene	50	270	5	27
75-27-4	Bromodichloromethane		-	-	-	-
10061-01-5	CIS-1,3-Dichloropropene		1	5	0.1	0.5
108-10-1	4-Methyl-2-Pentanone	Hexone [MIK]	50	205	5	20.5
10061-02-6	trans-1,3-Dichloropropene		1	5	0.1	0.5
79-00-5	1,1,2-Trichloroethane		10	45	1	4.5
108-88-3	Toluene		100	375	10	37.5
124-48-1	Dibromochloromethane		-	-	-	-
127-18-4	Tetrachloroethene	Tetrachloroethylene	25	170	2.5	17
108-90-7	Chlorobenzene		75	350	7.5	35
100-41-4	Ethylbenzene		100	435	10	43.5
75-25-2	Bromoform		0.5	5	0.05	0.5
100-42-5	Styrene		50	215	5	21.5
1330-20-7	Xylene (total)		100	435	10	43.5
79-34-5	1,1,2,2-Tetrachloroethane		1	7	0.1	0.7
74-87-3	Chloromethane	Methyl Chloride	50	105	5.0	10.5
74-83-9	Bromomethane	Methyl Bromide	5	20	0.5	2.0
75-01-4	Vinyl Chloride		5	10	0.5	1.0
75-00-3	Chloroethane	Ethyl Chloride	1,000	2,600	100	260
540-59-0	1,2-Dichloroethene (total)	1,2 Dichlorethylene	200	790	20	79
108-05-4	Vinyl Acetate		10	30	1	3
591-78-6	2-Hexanone		5	20	0.5	2

(1) Adopted from air contaminants - Permissible Exposure Limits (Title 29 CFR Part 1910.1000)
U.S. Department of Labor, Occupational Safety and Health Administration, 1989.

(2) TWA = 8 hour time weighted average.

(3) For indoor air quality guidelines the generally accepted practice is to assume that a concentration of 1/10th of the TLV would not produce complaints in a non-occupational population in residential and office environments (ASHRAE 62-1981R).

(4) Except in Exempt industries.

TABLE 7 - 1 m
TOTAL VOC CONCENTRATIONS DETERMINE BY
FLAME IONIZATION DETECTOR (FID)

Number/Room Usage	Instrument Reading (PPM) (1,2)	Rug Y/N	Sources Present
Print Shop (Arts)	ND-20	N	Solvents
Print Shop Storage	ND-10	N	Solvents
A316 Classroom	ND	N	
A317 Classroom	ND	Y	
Custodian Closet (arts 3rd)	ND	N	Cleaning agents
Corridor, Arts third floor	ND	N	Custodial cart
R211 Classroom	ND	N	
R212 Classroom	ND	N	
R213 Classroom	ND	N	
R214 Classroom	ND	N	
R215 Classroom	ND	N	
R216 Classroom	ND	N	
Custodian Closet (Arts 2)	ND	N	Cleaning agents
A106 Classroom	ND		
Electrical adjacent A108	ND	N	
Custodian Closet (Arts bid)	ND	N	Cleaning agents
Custodian Closed (Art bid)	10	N	Open can wax stripper
Theater (rear)	ND		
Corridor outside theater	ND		
Stage crafts workshop (A base - Arts)	ND		
Boys toilets (base - Arts)	ND		
Custodian Closet (basement)	ND		Cleaning agents

TABLE 7 - 1 m, Continued

Number/Room Usage	Instrument Reading	Rug Y/N	Sources Present
Electrical Closet (near A010)	ND		
A009	ND		
Pump room adjacent A009	ND		
Pump room adjacent A006	5ppm		"oily" smell
A005 and connected offices	ND		
Main Office and connected offices	ND		
R110 Office w/conference room	16ppm		
Head Custodian area	ND		Storage in back
Assistant principal's office	ND		
Print Shop (resurvey)	10ppm at top shelf (storage area) 2 ppm above press being cleaned with blanket wash <1 ppm background room		
A305 Corridor	10ppm		"cleaning odor"
Arts (3rd floor) walkway	100ppm		Window Wash (Robbins Pearl Shine Glass)
Head space of glass cleaner	>1000ppm		Head space of glass cleaner
Custodian Closet (R-ground floor)	<1ppm		Cleaning agents
Custodian Closet (ground floor)	500ppm		Head space of Robbins graffitti remover (main ingr. methylene chloride)
R110 (resurvey)	5ppm		
Copy Center (ground floor)	ND		3 copy machines
R131 Metal Fabrication Shop	5ppm General room 100ppm above paint solvent		Solvent

TABLE 7 - 1 m, Continued

Number/Room Usage	Instrument Reading	Rug Y/N	Sources Present
R131 Corridor	ND		
Boiler room corridor (R-2nd floor)	ND		
Boiler Room	20 ppm general room 50 ppm above oil drip pans		Oil
Student advocate office (Media)	ND		
Stairwell (Rindge side of bridge)	1 ppm		
Parking garage	ND		
R110 (resurvey) Supply Air Duct	14ppm 6 ppm		none observed
R111 Storage room	<1ppm		
Main Entrance	ND		
Student Advocate Office (re-test)	ND		
Cafe (entrance to Rindge)	ND		
Cafe Dishwashing area	ND		
Custodians Closet	ND		
Rindge Incinerator	ND		
Kitchen of Cantabrigia	ND		
R108 Storeroom	ND		
R108 (inside room)	0.5ppm		
R107 Carpentry Shop	ND		
R123 Electrical Shop	ND		
Media Center (lower level)	ND		
Custodian Closet (next to computer center)	ND		Cleaning agents
Computer Center	ND		
R202 Small office	ND		

TABLE 7 - 1 m, Continued

Number/Room Usage	Instrument Reading	Rug Y/N	Sources Present
R203 Small office	1ppm		newly waxed floor
R202 & R203 Corridor	2ppm		newly waxed floor
R204 Science classroom	1ppm		newly waxed floor
R205	1ppm		newly waxed floor
R206	1ppm		newly waxed floor
R207	1ppm		newly waxed floor
R211 Classroom	ND		floor washing
House "C" office	ND		
R218 Classroom	ND	Y	
R216 Classroom	ND	Y	
R215 Classroom	ND	Y	
R212 (Not surveyed locked)			
R222A Classroom Conference committee room	ND		40 students
R241 Career Resource Center	ND		
R245 House "B & C" Counselors Office	ND		
R249 Classroom	ND	Y	
R251 Typing Room	ND		
R252 Computer Room	ND		
R237 Small office	ND		
R258 Science Classroom	4ppm		no obvious sources
R257 Kitchen	10ppm	N	newly waxed floor
R256 Kitchen	11ppm	N	newly waxed floor
R255 Sewing classroom	4ppm		

TABLE 7 - 1 m, Continued

Number/Room Usage	Instrument Reading	Rug Y/N	Sources Present
R254 Home economics office	3ppm		duplicating fluid in cabinet
R253 Classroom (Infant Care)	ND	N	
Custodians Closet (Behind R252)	ND		Cleaning agents
R229 Classroom (windows open)	ND		
R228 Classroom (windows open)	ND		
R302 Small Classroom	ND	Y	
R304 Classroom	1ppm	N	floor waxed
R305 Classroom	1ppm	N	floor waxed
R306 Classroom	1ppm	N	floor waxed
R307 Classroom	1ppm	N	floor waxed
R308 Classroom	1ppm	N	floor waxed
R309 Small Office	1ppm		
R309 Classroom	ND		
R310 Small Office	1ppm	Y	appears to be from rug
R311 Small Classroom	ND		
R313 Windows open/no survey			
R314 Classroom	ND		
R315 Classroom	ND		
Greenhouse (windows open)	ND		
R315 Classroom	ND		
R315 Classroom	ND		
R333 Classroom	ND		
R334 Classroom	ND		

TABLE 7 - 1 m, Continued

Number/Room Usage	Instrument Reading	Rug Y/N	Sources Present
R335 Classroom	ND		
R336 Classroom	ND		
R337 Classroom	ND		
R403 Classroom	ND		
R404 Classroom	ND		
R417 Classroom	ND		
R421 Classroom	ND		
R422 Classroom	ND		
R425 Classroom	ND		
R427 to R431 Connected Offices	ND		
Field House (tennis courts)	ND		
R297	0.2ppm	N	dust control cmp'd in use
Spectator Booth	0.6ppm		"waxy" odor
Custodian room	ND		
Gym	ND		floor refinished
Corridor (Parallel to Cambridge Street)	ND		
Corridor	0.4ppm		pool custodian washing floor
Reception Desk	ND		
A. Powers Office	ND		
Entrance to boys locker room	ND		
Locker (boys)	ND		
Shower Room (boys)	ND		

TABLE 7 - 1 m, Continued

Number/Room Usage	Instrument Reading	Rug Y/N	Sources Present
Pool Office	ND		
Pool	ND		
R250 Typing Classroom	ND	Y	
R249 Typing Classroom	ND	Y	
Sheet Metal Shop	15 to 20ppm		solvent
R110 Office space	5ppm		
Corridor (adjacent to main office)	3ppm		floor wax ("Jackhammer") in use.

NOTES:

- (1) Calibrated as PPM methane.
- (2) All outdoor (ambient) readings were ND (non-detected).

This data indicates that there did not appear to be a general dispersion of VOC's from the sources into the general building air circulation. However, several areas had elevated VOC's which were identified with specific sources, as noted in Table 7-1m. VOC's were not detected in most of the occupied areas of the school.

7.2 Fiberglass Analysis

Glass Fiber Sampling

During the period from October 23 to November 2, 1989, samples of airborne fibers were collected from twenty-one locations in the Cambridge Rindge and Latin School. Sampling locations were selected based on areas in which the occupants had complained of both eye and throat irritation. Of the fibers sampled, glass fibers are of the most concern because studies have indicated that they may be responsible for the types of symptoms observed. (1, 2)

When possible, samples for fiber analysis were collected from the ventilation systems of the rooms sampled. Samples were collected within the duct for rooms serviced by rooftop units (RTUs), and within the unit ventilator (UV) for rooms serviced by UVs. Fiberglass insulation was observed lining the UVs. The entry ducts from the RTUs have fiberglass liners, and in some cases it was observed that loose insulation and other debris blocked the reheat coils. For rooms serviced by rooftop units in which the ducts were not accessible, an area sample in the room was collected. This sampling scheme attempted to define "worst case" conditions entering the room.

The sampling performed was intended as an initial survey of glass fiber concentrations within the School, and not as a definitive investigation. Additional sampling will be carried out. The association between ventilation systems lined with fibers like fiberglass and the concentrations of fibers in the rooms which the vents serve is not completely predictable. While it is logical that air inflows entering a room will carry loose fibers from the duct lining into the room, this may not always be the case. Ventilation systems lined with fibers have also been shown to trap rather than to release fibers, with the result that fiber concentrations in the supply air are lower than concentrations in the room air. Thus, resuspension might cause room air to have a higher concentration than duct air.

Samples were collected on mixed cellulose ester filters with a pore size of 0.8 μm . A conductive cowl was used on the filter inlet to minimize static charge effects. Area samples were collected using calibrated pumps with a nominal collection rate of 10 liter/min. Duct and UV samples were collected using battery operated "personal" pumps with a nominal flow rate of 2.6 liters/min.

Analysis of the samples collected provided quantification of the total fiber concentration and an estimate of the percentage of the fibers in each sample which were glass fibers. Analysis was carried out by a laboratory accredited by the National Voluntary Laboratory Accreditation Program of the National Institute of Technology and Standards. The analysis method used to determine the total fiber concentration was NIOSH method 7400. The fiber identification method used was polarized light microscopy (EPA Interim Method as defined in Appendix A to Subpart F-40).

Interpretation of Results

No glass fibers were detected in most of the samples collected (Table 7-2). Of the samples collected, only the unit ventilator sample from R233, with a concentration of 1,580 f/m³,

and the area sample from room R 245, with a concentration of 300 f/m³, represent concentrations which are above typical indoor levels of 10 to 100 f/m³.

Industry concentrations are typically 10,000 to 1,000,000 f/m³ (Schneider, Esmen), and the current NIOSH guideline for occupational exposure is 2,000,000 f/m³. Even at occupational levels, there is no definitive evidence which correlates glass fiber exposure to chronic health effects.(Beavers, 1988))

Information on the acute effects of glass fibers in indoor, non-industrial environments is limited. However, research studies indicate that airborne glass fibers tend to accumulate in the eye, which suggests that with long exposure times, eye irritation could occur even with low airborne concentrations.(Schneider, 1981) The results of a recent Danish study indicate that symptoms of eye irritation and inflammation may occur more frequently at airborne glass fiber concentrations as low as 150 f/m³.(Rindel, 1987) However, this work requires further verification.

**TABLE 7.2 RESULTS OF FIBERGLASS SAMPLING AT
CAMBRIDGE RINDGE & LATIN SCHOOL**

ROOM #	TYPE OF SAMPLE	VOLUME (LITERS)	FIBER CONC. (f/m ³)	FIBER % GLASS	GLASS FIBER CONC. (f/m ³)
R341	AREA	2039	500	ND	ND
R342	AREA	1862	300	10%	30
R344	UV	1962	1600	ND	ND
A302	UV	976	1300	ND	ND
PRINT SHOP	AREA	1973	0	ND	ND
R233	UV	1272	7900	20%	1,580
R318	UV	412	7700	ND	ND
A220	AREA	1049	7500	ND	ND
A212	AREA	2420	3200	ND	ND
R508	AREA	2098	100	ND	ND
R406	AREA	2273	900	ND	ND
R217	UV	1136	500	5%	25
R220	UV	718	100	ND	ND
R221	UV	941	300	ND	ND
R114	AREA				
R118	AREA	3139	200	ND	ND
R218	AREA	2038	3900	ND	ND
R245	AREA	1646	6000	5%	300
PRINT SHOP	DUCT	2340	200	20%	40
R339	DUCT	1420	300	ND	ND
R335	DUCT	1400	400	1%	4

7.3 Airborne Formaldehyde Concentrations

Samples to determine the formaldehyde concentrations in air were collected from several locations throughout the CRLS facility. Locations were chosen to represent a variety of occupant usage. No special outside air settings were maintained during the testing period. Testing was carried out on 29, 30 and 31 August 1989. The office doors were closed during the testing procedure to minimize the influence of the different activities going on outside the test space.

Eighteen sample locations were chosen throughout the CRLS facility, with one outside location. Samples were collected using Air Technology Labs passive dosimeters. To check the accuracy of these dosimeters additional active samplers were collected using NIOSH method 3500 (NIOSH manual of Analytical Methods, third ed., 1984). Good agreement was found between the two methods. The results for the passive dosimeters are presented in Table 7-3.

All of the areas sampled fall well below the Current American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) guidelines of 0.1 ppm ($120 \mu\text{g}/\text{m}^3$) of gaseous formaldehyde in occupied spaces. This result is not unexpected since there were no obvious sources such as new furnishings present in the area. We would expect off gassing of materials in the space to have occurred in the years after their initial installation.

TABLE 7-3

RESULTS OF FORMALDEHYDE ANALYSIS OF SAMPLES COLLECTED AT CRLS
FACILITY, CAMBRIDGE, MASSACHUSETTS

Sample #	Location	Concentration (ppm) ¹	Comments
1	Student Service Center offices	0.066	on door between
2	Student Service Center	0.034	on desk
3	Print Shop, Art	0.090	floor being cleaned
4	A318	0.018	rug
5	Walk Way, 3rd Floor between Art and Rindge building	0.051	
6	Media Center, 3rd Floor	0.018	
7	R305 0.011 Biology Lab		
8	R207 .013 Physics Lab		
9	Custodian Office, Rindge	0.016	
10	R110	0.022	Administration Office
11	Main Office, Rindge	0.013	
12	Dr. Magan's Office	0.024	
13	Copy Center, Rindge	0.018	rug washed previous day
14	Day Care Center, Rindge	0.015	
15	Health Center, Rindge	0.026	near records storage
16	Main Cafeteria, Rindge	0.015	near telephones
17	Woodworking Shop, Rindge	0.014	
18	R317	0.018	near door to greenhouse

¹ (concentrations = PPMv formaldehyde in air)

7.4 Respirable Suspended Particulate Matter (RSP)

To sample particles at selected locations in the Cambridge Rindge & Latin School, a micro-environmental exposure monitor (MEM), which was developed for measuring respirable suspended particles was used. This consisted of two major components: a size-selective particle sampling device, and a flow regulated pump.

For purposes of sampling at CRLS, the aerodynamic cut size was selected to be $2.5\ \mu\text{m}$. This size cut is most representative of particles which are inhaled and retained by the human respiratory tract and hence have the major impact on human health. Particles less than $2.5\ \mu\text{m}$ are commonly referred to as respirable suspended particles (RSPs).

A $2\ \mu\text{m}$ pore-size, PTFE (Teflon), 41 mm filter disk with a polyolefin ring (Teflo #R2PJ041, Gelman) is mounted in a 51 mm x 51 mm standard Beckman-type frame and is used as a particle collection medium. The downstream side of the filter is supported by cellulose backing material.

All gravimetric filters collected for analysis at CRLS were weighed in an environmentally controlled room (25°C , 50% RH). A Cahn microbalance was used to weigh the MEM filters. Filters were conditioned in the balance room for at least 24 hours before both tare and final weighing to reduce the humidity effects of the filter masses. To quality assure the data, a subset of filters were subjected to laboratory handling, but did not leave the weighing laboratory. These filters were reweighed as normal filters to assure that large mass changes were not being introduced in the weighing process. Filters treated in this way showed differences between tare and final weighings of $4\ \mu\text{g}$ or less. Likewise, filters were prepared which were taken to the field, but not exposed. Filters treated in this way showed differences between tare and final weighings of $10\ \mu\text{g}$ or less, indicating that for the sample period of one week, the 95% confidence interval for the concentrations reported is on the order of $8\ \mu\text{g}/\text{m}^3$.

Table 7-4 shows the results of respirable mass measurements made in CRLS. These measurements represent a time weighted average exposure covering the period between June 17, and June 24, 1989. The samplers were operational between 0800 hours and 1600 hours (typical school hours). The range of RSPs measured range from 13.4, and $30.8\ \mu\text{g}/\text{m}^3$. This range of RSPs is well within the limits of expected values in non-smoking environments. For reference, the current EPA regulation for inhalable particulate matter is $150\ \mu\text{g}/\text{m}^3$. Notable is the fact that the RSP levels measured indoors in all but one case were less than the ambient measurement of $30.2\ \mu\text{g}/\text{m}^3$. This ambient RSP sample was collected near the outdoor air inlet to RT-6, located on the roof of the Arts Building.

7.5 Analysis for Fungi and Bacteria

Sampling for airborne microorganisms in Cambridge Rindge & Latin School buildings was carried out using an Andersen N6 impactor. Eighteen locations were chosen for sampling. The sampling was conducted on Friday, 20 August 1989. Samples were collected on malt extract agar and sent to the University of Michigan for culturing and analysis by Dr. Harriet Burge. The results are presented in Table 7-5a.

Malt extract agar is used for the detection and enumeration of fungi. Malt extract agar has several benefits for culturing fungi, including:

1. It is a diagnostic media for the identification of *Aspergillus* species,
2. It does not support growth of most bacteria.

In general, bacteria found indoors are derived from interior sources and human activities. Fungal spores occur naturally outdoors; however, if proper conditions are present indoors, fungi can flourish and serve as a major source of contamination. In general, the evaluation of fungal spores is done by comparing indoor levels to those found outdoors. In this manner, possible amplification of fungal spores from interior reservoirs can be detected. It is also important to compare the relative rank order of taxa found indoors to those found in outdoor samples to assess the possibility of indoor contamination.

Airborne cultural fungi recovered in all indoor locations were similar in composition and concentration to outdoor recoveries. Based on this one sampling period, it appears that there is no airborne indoor fungal contamination. However, for room R244, the levels indicated moderate contamination which is probably due to water damaged rugs. These should be removed and disposed.

7.5.1 Source Measurements

A series of bulk samples were collected from areas believed to have a high potential to be a reservoir for fungi. Samples were suspended, diluted, and inoculated onto malt extract agar (MEA) for fungi (room temperature incubation), nutrient agar for bacteria (30°C), and TSA for thermophilic bacteria and actinomycetes (56°C). The results are presented in Table 7-5b.

Concentrations of thermophiles were low in all samples. Nutrient agar showed low concentrations of bacteria in most samples. Fungal concentrations were low in all samples.

Table 7-4

Results of Respirable Suspended Particle Measurements at Cambridge Rindge & Latin School.

Location	RSP Concentration $\mu\text{g}/\text{m}^3$
A002	13.4
A001	13.5
A318	13.5
A107	14.0
Aud (rhs)	14.5
R336	15.0
Aud (lhs)	15.1
A009	16.3
A106	17.3
R204	21.7
R130	21.9
A209	22.2
R113	22.6
R223	23.2
R506	23.8
R405	23.8
R417	23.9
R136	24.1
R504	24.1
R410	24.7
R226	24.7
R400	24.8
R421	24.9
R333	24.9
A204	25.1
R205	25.5
A109A	25.6
A305	25.6
A205	25.7
R110	26.3
R318	27.3
R245	27.3
R315	27.5
A101	27.7
A219	28.2
A302	28.5
Ambient	30.2
A212	30.8

Table 7-5a Results of Airborne Microbiological Analysis of Samples Collected at Cambridge Rindge and Latin School, Cambridge, Massachusetts.⁽¹⁾

Sample #	Location	CFU/m ³ (2)	Taxa (CFU/Plate) ⁽⁶⁾
1	Rm A001	33	fungi: ns ⁽⁵⁾ (2) penicillium (1) Aspergillus versicolor (1) yeast (1)
		7	bacterium (1)
2	Rm A001	27	fungi: Penicillium (2) Rhinochadiella (1) ns (1)
3	Rm A003	13	fungi: Cladosporium (1) unknown (1)
		60	bacterium
4	Rm A106	80	fungi: yeast (3) Cladosporium (2) Penicillium (2) unknown (2) Aspergillus niger (1) Rhinochadiella (1)
		7	bacterium (1)
5	Rm A106	67	fungi: Cladosporium (2) Penicillium (2) yeast (2) Rhinochadiella (1) ns (1)
6	Rm A212	247	fungi: Cladosporium (18) yeast (4) Penicillium (3) ns (3) Aspergillus versicolor grp (1) unknown (1) Rhinochadiella (1) Aureobasidium (1)
7	Rm 213/209	93	fungi: yeast (9) Cladosporium (4) Rhinochadiella (1)

Table 7-5a, Continued

Sample #	Location	CFU/m ³ (2)	Taxa (CFU/Plate)(6)
8	Rm 213/209	53	fungi: Cladosporium (2) Rhinoctadiella (2) Penicillium (1) yeast (1) ns (1) Aspergillus fumigatus (1)
		7	bacteria
9	Rm A220	93	fungi: Cladosporium (5) Penicillium (4) Aspergillus fumigatus (2) ns (1) Rhinoctadiella (1)
10	Rm A309	220	fungi: Cladosporium (15) yeast (4) unknown (4) ns (3) Penicillium (2) Aspergillus niger (1) Aspergillus fumigatus (1) Fusarium (1)
11	Rm A309	140	fungi: ns (10) Cladosporium (5) Penicillium (2) Alternaria (1) Aspergillus fumigatus (1) Aspergillus niger (1)
12	Rm A310	87	fungi: Cladosporium (5) Penicillium (3) ns (2) Alternaria (2) Aspergillus niger (1)
		7	bacterium (1)
13	Boys' Room, 3rd Fl Arts	87	fungi: yeast (9) Cladosporium (4)
14	Boys' Room 3rd Fl Arts	47	fungi: yeast (5) Cladosporium (1)

Table 7-5a, Continued

Sample #	Location	CFU/m ³ (2)	Taxa (CFU/Plate) ⁽⁶⁾
=====			
			Penicillium (1)
15	Health Center	133	fungi: Cladosporium (5) Pithomyces (3) ns (3) yeast (3) Alternaria (2) Penicillium (2) Aureobasidium (1)
		7	bacterium
16	Daycare Rm 130	100	fungi: Cladosporium (14) Penicillium (4) Zygomycete (1) (covering plate) Aspergillus sp (1)
17	Daycare Rm 130	180	fungi: Cladosporium (14) Penicillium (6) ns (5) Aspergillus versicolor grp (1)
18	Rm 244	767	fungi: Penicillium (93) Cladosporium (6) Botrytis (1)
19	Rm R325	126	fungi: Cladosporium (11) Penicillium (4) ns (3)
		21	bacteria (3)
20	Rm R325	160	fungi: Cladosporium (9) Penicillium (6) unknown (4) ns (4)
21	Rm 400	167	fungi: Cladosporium (16) Penicillium (5) Aureobasidium (1) yeast (1) ns (1)
22	Rm R427	166	fungi:

Table 7-5a, Continued

Sample #	Location	CFU/m ³ (2)	Taxa (CFU/Plate) ⁽⁶⁾
			Cladosporium (8) Penicillium (8) ns (6) yeast (2) bacteria (2)
23	Rm R427	107	fungi: Cladosporium (7) Penicillium (4) ns (4) Aspergillus fumigatus (1)
24	Phys. Ed. Office	113	fungi: Cladosporium (7) Penicillium (5) yeast (2) ns (2) Alternaria (1)
25	Phys. Ed. Office	107	fungi: ns (6) Penicillium (4) Cladosporium (3) yeast (2) Aspergillus fumigatus (1)
		13	bacteria (2)
26	Outside Background	407	fungi: Cladosporium (32) Penicillium (7) Alternaria (4) Aureobasidium (3) Pithomyces (2) ns (2) Rhizopus (1) Epicoccum (1) Aspergillus fumigatus (1) Aspergillus sp (1) yeast (1) Botrytis (1) unknown (1)
27	Background	393	fungi: Cladosporium (31) Penicillium (7) ns (7) unknown (4) Botrytis (3) Epicoccum (2)

Table 7-5a, Continued

Sample #	Location	CFU/m ³ (2)	Taxa (CFU/Plate)(6)
=====			
			Aureobasidium (1)
28	Pool	186	fungi: Penicillium (9) Cladosporium (4) unknown (4) yeast (3) ns (2) Alternaria (2) Aspergillus niger (1) Aspergillus fumigatus (1) Aspergillus sp (1)
		7	bacterium (1)

NOTES:

- (1) Sampling media was malt extract agar, room temperature incubation for fungi. CFU/plate counts are for comparisons within plates only.
- (2) CFU/m³ = colony forming units per cubic meter of air samples.
- (3) Sample volume for all samples was 141.5 L (5 min sample at 28.3 L/min)
- (4) CFU = colony forming unit
- (5) ns = non-sporulating
- (6) CFU/plate counts are for comparisons within plates only.

Table 7-5b Results of Bulk Sample Analysis for Microbiological Contaminants on Three Media for Samples Collected at Cambridge Rindge and Latin School, Cambridge, Massachusetts.

Malt Extract Agar (Room Temperature incubation)

Sample #	Location	CFU/gm	Taxa (CFU)
CR 1	Drip pan RT 5	8.58 x 10 ⁵ >1.23 x 10 ⁷	fungi: ns (21) bacteria (>300)
CR 2	Filter RT5	2.55 x 10 ^{4**}	fungi: Aureobasidium (0.5) Cladosporium (0.5) ns (0.5)
CR 3	Drip Pan RT4	1.91 x 10 ⁶ 1.99 x 10 ⁵	fungi: ns (48) bacteria (5)
CR 4*	Drip Pan RT6	4.77 x 10 ⁵ 4.54 x 10 ⁴	fungi: basidiomycetous yeast (52.5) bacteria (5)
CR 5	Linear RT6	4.71 x 10 ⁴	fungi: yeast (2)
CR 6	3rd Flr Return RT4 (Linear)	6211	fungi: Aspergillus niger (0.5)
CR 7	3rd Flr Supply RT4 (Linear)	<1.15 x 10 ⁴	fungi: (0)
CR 8	Chorale Rm (Tektum)	1095	fungi: unknown (0.5)
CR 9	P. Callan Office (Tektum) (Chor Rm)	4.18 x 10 ⁵ 1.04 x 10 ⁴	fungi: unknown 120.5 bacteria: (3)

* Sample wet when received

** Alternative concentration by area: 644 CFU/cm²

Table 7-5b, Continued

Nutrient Agar (30°C Incubation)

Sample #	Location	CFU/gm	Taxa (CFU)
CR 1	Drip pan RT5	$>1.43 \times 10^8$	bacteria (>3500)
CR 2	Filter RT5	1.70×10^5 **	bacteria (1)
CR 3	Drip Pan RT4	$>1.39 \times 10^8$	bacteria (>3500)
CR 4*	Drip Pan RT6	$>3.18 \times 10^7$	bacteria (>3500)
CR 5	Linear RT6	4.71×10^5	bacteria (2)
CR 6	3rd Flr Return RT4 (Linear)	<6200 1.24×10^4	bacteria (0) fungi (1)
CR 7	3rd Flr Supply (Linear)	$<1.15 \times 10^4$	bacteria (0)
CR 8	Chorale Rm (Tektum)	<1095 2191	bacteria (0) fungi (1)
CR 9	P. Callan Office (Tektum) (Chor Rm)	3.65×10^4	bacteria (10.5)

* Sample wet when received

** Alternative concentration by area: 4296 CFU/cm²

Table 7-5b, Continued

Tryptocase Soy Agar (56°C Incubation)

Sample #	Location	CFU/gm	Taxa (CFU)
CR 1	Drip pan RT5	<2044 4087	actinomycetes (0) bacteria (1)
CR 2	Filter RT5	<8511** 8511	actinomycetes (0) bacteria (0.5)
CR 3	Drip Pan RT4	<1988	actinomycetes (0)
CR 4*	Drip Pan RT6	<454	actinomycetes (0)
CR 5	Linear RT6	<1.18 x 10 ⁴ 1.18 x 10 ⁴	actinomycetes (0) bacteria (0.5)
CR 6	3rd Flr Return RT4 (Linear)	<6211	actinomycetes (0)
CR 7	3rd Flr Supply (Linear)	<1.15 x 10 ⁴	actinomycetes (0)
CR 8	Chorale Rm (Tektum)	<1095	actinomycetes (0)
CR 9	P. Callan Office (Tektum) (Chor Rm)	<1736	actinomycetes (0)

* Sample wet when received

** Alternative concentrations by area:

<215 CFU/cm ²	(actinomycetes)
215 CFU/cm ²	(bacteria)

7.6 Carbon Dioxide Measurements

Carbon Dioxide (CO₂) measurements have been taken at various times and locations in the Cambridge Rindge & Latin School. The dominant source of CO₂ observed in indoor locations is from exhaled breath of human occupants. Monitoring the CO₂ concentrations at various locations in the building, and noting the number of occupants present, provides an indication of the adequacy of ventilation provided to remove occupant generated bio-effluents.

CO₂ measurements were made using a GasTech Model RI-411 Portable CO₂ monitor. This instrument was zeroed prior to each use using a soda lime scrubber, and its sensitivity determined using Certified Gas Standards.

The results of the survey are detailed in Table 7-6. As a point of reference, ASHRAE recommends levels of 1000 PPM_v of CO₂ as the acceptable limit in enclosed spaces (ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality). This value corresponds to approximately 15 cubic feet per minute of outside air per person supplied to the occupied spaces. See Section 6.3 for the rationale behind and implications of this guideline.

The choice of where and when CO₂ measurements were made was primarily in response to complaint data. These complaints were received on a standard form circulated amongst faculty and staff at the beginning of the 1989 fall term. Monitoring personnel tried to visit the complaint areas near the complaint time indicated. If the complaint was for a classroom, then CO₂ was monitored during classroom activities.

One observes that the CO₂ guideline was rarely exceeded in the building. Locations in which the 1000 PPM_v CO₂ guideline was observed to have been exceeded include rooms R221, R228, R342, & R424. Of these rooms, it is notable that R221, R228, & R424 are serviced by Unit Ventilators. Room R342 is serviced by RT-9. As most of these observations were made in late September through Mid-October of this year, it is probable that these observations were made before the coils of the Unit Ventilators and Roof-Top Units were cleaned. As this remediation action nears completion, follow-up measurements will be made to gauge the effectiveness of the remediation steps taken.

Table 7-6 lists the temperature and relative humidity observations that were made coincident with the CO₂ measurements. These measurements indicate that in all but a few areas, the thermal comfort conditions in the areas measured were within the summer thermal comfort envelope described by ASHRAE Standard 55-1981 (Thermal Environmental Conditions for Human Occupancy).

Of the areas measured, rooms A101, A204, R216, R325, and R204 were observed to have thermal conditions warmer than allowed by ASHRAE Standard 55-1981.

Four of the five areas in which the thermal conditions were observed to be warmer than conditions specified by the thermal comfort envelope of ASHRAE 55-1981, are serviced by Unit Ventilators. These rooms, noted as rooms A101, A204, R216 and R325 are, by design of the unit ventilators not capable of providing cooling to the space. The remaining area observed to be warmer than the thermal comfort envelope, Room R204, is serviced by RT-13. During the period of measurement, both of RT-13's compressors were out of service. Currently compressors are on order for installation in RT-13.

Table 7-6 Carbon Dioxide, Temperature and Relative Humidity Measurements from Cambridge Rindge & Latin Schools.

Date	Time	Room	CO2 PPM	T oF	RH %	Persons Present
9/29/89	12:40	A007	429	77	40	0
9/29/89	13:29	A007	670	77	40	30
9/29/89	14:22	A007	670	77	42	30
9/29/89	12:44	A101	429	78	39	0
9/29/89	13:30	A101	718	81	38	14
9/29/89	14:18	A101	622	81	36	16
9/29/89	12:48	A204	332	80	37	0
9/29/89	13:37	A204	429	81	36	20
9/29/89	14:27	A204	574	80	37	20
10/19/89	13:54	A318	718	78	34	15
10/19/89	14:19	A318	718	76	36	1
10/19/89	14:40	A318	670	77	35	2
10/10/89	13:51	R102	381	74	25	12
10/10/89	14:26	R102	670	75	26	0
10/10/89	14:30	R102	381	74	23	3
10/20/89	13:02	R110	767	74	57	4
10/20/89	13:29	R110	525	75	58	6
10/20/89	13:49	R110	525	75	61	3
10/20/89	14:15	R110	429	77	62	2
10/16/89	13:04	R114	718	74	56	9
10/16/89	13:38	R114	767	75	55	10
10/16/89	14:16	R114	622	76	58	8
10/10/89	14:35	R118	670	75	26	2
10/11/89	13:15	R118	767	77	36	3
10/11/89	13:51	R118	670	76	36	3
10/11/89	14:30	R118	718	76	35	4
10/20/89		R119	525			
9/29/89	12:55	R204	670	80	38	16
9/29/89	13:48	R204	429	82	37	0
9/29/89	14:34	R204	381	82	35	2
10/11/89	13:01	R204	622	74	41	13
10/11/89	13:42	R204	525	75	40	15
10/11/89	14:23	R204	381	72	38	0
9/29/89	13:00	R216	622	78	41	0
9/29/89	13:53	R216	670	81	36	0
9/29/89	14:44	R216	622	80	35	0
10/16/89	13:32	R218	767	73	59	12
10/16/89	14:11	R218	622	75	58	0
10/16/89	12:57	R218	429	72	57	0
10/10/89	13:35	R220	911	75	28	18
10/10/89	14:10	R220	960	74	28	14
10/11/89	12:57	R220	574	74	41	15
10/11/89	13:37	R220	767	75	41	14
10/11/89	14:19	R220	767	73	41	11
10/10/89	13:40	R221	1490	75	32	22
10/10/89	14:13	R221	815	74	28	0
10/11/89	13:35	R221	1104	75	43	26

Table 7-6 Carbon Dioxide, Temperature and Relative Humidity Measurements from Cambridge Rindge & Latin Schools.

Date	Time	Room	CO2 PPM	T oF	RH %	Persons Present
10/11/89	14:06	R221	622	73	40	2
10/11/89	12:50	R221	863	74	42	18
10/16/89	13:50	R221	863	75	59	0
10/16/89	14:05	R221	670	75	60	0
10/19/89	14:07	R221	525	73	38	0
10/19/89	14:28	R221	574	73	39	0
10/20/89	12:49	R223	429	76	55	0
10/20/89	13:17	R223	550	76	58	6
10/20/89	13:41	R223	525	76	59	4
10/20/89	13:57	R223	574	78	62	4
10/10/89	13:48	R228	1008	75	28	18
10/10/89	14:19	R228	622	74	28	3
10/11/89	13:10	R228	815	76	42	18
10/11/89	13:48	R228	863	75	40	2
10/11/89	14:27	R228	622	73	40	0
10/19/89	14:11	R228	718	74	39	0
10/19/89	14:32	R228	622	74	39	0
10/16/89	12:51	R229	622	73	53	8
10/16/89	13:26	R229	815	74	58	19
10/16/89	14:08	R229	670	75	58	0
10/19/89	14:13	R229	477	74	34	0
10/19/89	14:35	R229	477	74	34	0
10/20/89	12:54	R241	767	75	57	12
10/20/89	13:21	R241	767	74	52	7
10/20/89	13:43	R241	791	75	54	6
10/20/89	14:10	R241	815	76	56	8
10/20/89	13:24	R244	767	74	59	13
10/10/89	13:46	R245	670	74	30	5
10/16/89	12:45	R245	622	72	53	0
10/16/89	13:58	R245	622	75	55	4
10/16/89	13:19	R245	622	73	52	5
10/16/89	12:41	R250	429	73	57	0
10/16/89	13:15	R250	477	74	56	0
10/16/89	13:55	R250	525	74	59	4
10/31/89	09:29	R250	574	77	56	21
10/31/89	09:32	R250	622	78	56	21
10/31/89	09:59	R250	622	77	55	21
10/31/89	10:06	R250	622	77	56	21
10/31/89	10:13	R250	622			
10/10/89	13:43	R254	718	75	27	3
10/10/89	14:16	R254	670	73	28	5
10/20/89	12:47	R314	574	77	51	2
10/20/89	13:14	R314	863	77	53	12
10/20/89	13:39	R314	863	77	56	2
10/10/89	13:32	R316	646	76	23	12
10/10/89	14:03	R316	574	76	23	0
9/29/89	13:05	R325	622	83	36	12

Table 7-6 Carbon Dioxide, Temperature and Relative Humidity Measurements from Cambridge Rindge & Latin Schools.

Date	Time	Room	CO2 PPM	T oF	RH %	Persons Present
9/29/89	13:59	R325	622	83	36	0
10/16/89	12:35	R329	622	74	55	0
10/16/89	12:32	R334	332	72	59	0
10/16/89	13:09	R334	381	73	58	0
10/16/89	13:42	R334	381	74	58	0
10/10/89	13:28	R342	863	78	26	14
10/10/89	14:00	R342	622	77	26	0
10/11/89	12:43	R342	718	77	37	0
10/11/89	13:25	R342	1056	76	41	15
10/11/89	13:57	R342	767	76	37	0
10/19/89	14:03	R342	767	75	37	0
10/19/89	14:24	R342	767	74	38	0
10/20/89	12:44	R344	550	74	59	0
10/20/89	13:11	R344	622	75	60	17
10/20/89	13:37	R344	815	74	65	17
10/20/89	12:40	R406	574	76	54	3
10/20/89	13:05	R406		75	59	3
10/20/89	13:31	R406	670	71	68	0
10/10/89	13:23	R411	525	78	22	4
10/10/89	13:58	R411	622	77	23	3
10/20/89	13:08	R424	767	75	61	18
10/20/89	13:35	R424	960	73	66	18
10/20/89	13:54	R424	1008	77	66	23
10/20/89	14:18	R242	1056	77	66	23
9/29/89	13:13	R512	767	82	38	12
9/29/89	14:04	R512	574	82	36	4
10/10/89	13:55	Safety Office	863	77	26	7

7.7 Carbon Monoxide Monitoring

Carbon monoxide levels (CO) were monitored in the Cambridge Rindge & Latin School parking garage on October 4 and 5 and December 6 and 7, 1989, using a calibrated Interscan CO monitor with a chart recorder. The Interscan "HI" range was used, which records concentrations between 0 and 100 ppm. The unit was calibrated using a 51.2 ppm certified calibration gas. Appropriate conversion factors were considered when interpreting the data collected.

October 4 and 5, 1989

The first sampling period was from 8:15 am October 4 through 9:00 am October 5. The Interscan monitor was located during the entire period in the storage closet near the ramp leading from the parking garage to the entrance of the school. Teflon tubing was used to extend the air intake for the Interscan to the wall just around the corner of the closet. The inlet was at breathing height.

December 6 and 7, 1989

Sampling was again conducted in the parking garage during the period from 4:00 pm December 6 through 4:50 pm December 7. The Interscan monitor was located in the storage closet near the entrance ramp throughout most of the sampling. However, between 12:20 and 3:20 on December 7th the instrument was carried to different locations in the parking garage to check for any areas which might have elevated CO concentrations. No areas of elevated CO concentrations were found. See Table 7.7 for tabulated CO concentrations measured during this walk-around survey.

Results

The highest concentrations recorded during the sampling periods were about 60 ppm. These peaks lasted only about a minute, which indicates that they were probably due to a car driving by or starting up next to the instrument's inlet. The baseline concentration in the garage was about 2 ppm. During peak traffic hours, CO concentrations rose to about 10 ppm, but were not sustained at levels near 10 ppm for more than 30 minutes. These concentrations are normal and do not represent a hazard with reference to the Primary National Ambient Air Quality Standard of 9 ppm for an 8 hour exposure.

The large exhaust fans in the garage were observed to be off during the times Environmental Health & Engineering personnel were in the garage (8-9 am, 6 pm on October 4 and 5). Mr. Jeff Fahey of Bay State York was contacted after testing regarding the schedule that fans in the parking garage were on. According to Mr. Fahey, the fans should be operating at peak traffic hours, between about 8 and 9:30 am and 2 and 3:30 pm. After checking the timer on the fan control unit, Mr. Fahey reported that the fans were running approximately four hours behind schedule, and were running from about 4 to 5:30 in the morning and from 10 to 11:30 in the afternoon. Mr. Fahey reported that he corrected the fan timers.

TABLE 7-7 CO MEASUREMENTS

DATE	TIME	LOCATION	CO CONCENTRATION	COMMENTS
12/6/89	12:20	1	8	NO CARS RUNNING
12/6/89	12:23	2	8	NO CARS RUNNING
12/6/89	12:25	3	16	CAR STARTED 20FT AWAY
12/6/89	12:28	4	8	NO CARS RUNNING
12/6/89	12:31	5	8	CAR RUNNING 30-40 FT AWAY
12/6/89	12:34	6	8	CAR RUNNING 15-20 FT AWAY
12/6/89	12:37	7	8	NO CARS RUNNING
12/6/89	12:40	8	11.2	NO CARS RUNNING
12/6/89	12:43	9	8	NO CARS RUNNING
12/6/89	12:46	10	9.6	NO CARS RUNNING
12/6/89	12:49	11	8	NO CARS RUNNING
12/6/89	12:52	12	8	1 CAR RUNNING 10-15 FT AWAY
12/6/89	13:13	1	9.6	NO CARS RUNNING
12/6/89	13:15	2	17.6	NO CARS RUNNING
12/6/89	13:18	3	12.8	A FEW CARS LEAVING
12/6/89	13:21	4	9.6	NO CARS RUNNING
12/6/89	13:24	5	8	1 CAR EXITING
12/6/89	13:27	6	8	NO CARS RUNNING
12/6/89	13:30	7	8	1 CAR EXITING
12/6/89	13:33	8	8	NO CARS RUNNING
12/6/89	13:36	9	8	NO CARS RUNNING
12/6/89	13:39	10	12.8	
12/6/89	13:42	11	8	NO CARS RUNNING
12/6/89	13:45	12	8	1 CAR EXITING
12/6/89	14:21	1	9.6	NO CARS RUNNING
12/6/89	14:23	2	9.6	CARS STARTING TO EXIT
12/6/89	14:26	3	8	CARS STARTING TO EXIT
12/6/89	14:29	4	51.2	CARS STARTING TO EXIT
12/6/89	14:31	5	16	CARS STARTING TO EXIT
12/6/89	14:34	6	17.6	CARS STARTING TO EXIT
12/6/89	14:37	7	16	CARS STARTING TO EXIT
12/6/89	14:39	8	36.8	CARS STARTING TO EXIT
12/6/89	14:42	9	30.4	CARS STARTING TO EXIT
12/6/89	14:44	10	14.4	CARS STARTING TO EXIT
12/6/89	14:46	11	22.4	CARS STARTING TO EXIT
12/6/89	14:49	12	17.6	CARS STARTING TO EXIT
12/6/89	14:52	1	11.2	CARS STARTING TO EXIT
12/6/89	14:55	2	11.2	CARS STARTING TO EXIT
12/6/89	14:57	3	9.6	CARS STARTING TO EXIT
12/6/89	14:59	4	14.4	CARS STARTING TO EXIT
12/6/89	15:01	5	12.8	NO CARS RUNNING
12/6/89	15:03	6	8	NO CARS RUNNING
12/6/89	15:06	7	8	NO CARS RUNNING
12/6/89	15:08	8	8	CARS EXITING
12/6/89	15:11	9	11.2	CARS EXITING
12/6/89	15:13	10	8	CARS EXITING
12/6/89	15:17	11	9.6	CARS EXITING
12/6/89	15:20	12	8	CARS EXITING

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Appendix A

Limitations

1. Environmental Health and Engineering's indoor air assessment was performed in accordance with generally accepted practices of other consultants undertaking similar studies at the same time and in the same geographical area and EHE observed that degree of care and skill generally exercised by other consultants under similar circumstances and conditions. The observations described in this Report were made under the conditions stated therein. The conclusions presented in the Report were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by Client.
2. The conclusions and recommendations contained in this report are based on limited environmental sampling and visual observation, and were arrived at in accordance with generally accepted standards of industrial hygiene practice. The sampling conducted at the site was limited in scope, and therefore cannot be considered representative of areas not sampled.
3. Where sample analyses were conducted by an outside laboratory, EHE has relied upon the data provided, and has not conducted an independent evaluation of the reliability of these data.
4. The purpose of this report was to assess the characteristics of the subject site as stated within this report. No specific attempt was made to check on the compliance by any party with all federal, state or local laws and regulations.
5. Observations were made of the site as indicated within the Report. Where access to portions of the site was unavailable or limited, EHE renders no opinion as to the presence of chemical residues, or to the presence of indirect evidence relating to chemical residues in that portion of the site.

APPENDIX B

Survey of Room Conditions

In late August, a visual survey was conducted in each room of the Rindge and Arts building to assess the condition of the rugs, and observe the presence of water damage, if any. Table B-1 is a list of rooms that were surveyed in the complex. This Table presents the various observations that were made in each room with respect to the condition of the physical condition of the space. The qualitative measures of damage have each been assigned a column. Column A is the area being referred to. Column K indicates (with a check mark) whether carpeting was in the room at the time of the inspection or not. Column L is the "cumulative score" assigned to the rooms. The higher the "score" the greater the potential for problems. This "score" can be used to prioritize removal of carpets from the rooms, and additional work that may be needed to repair water damaged walls.

Summary of Airflow Measurements Prior to Remediation

An integral part of the assessment of the HVAC system at the CR&L School has been the measurement of the total supply and exhaust air into each room of the Rindge & Arts Buildings. Table B-1 presents the results of the measurements made before remediation steps which were taken to improve the operating condition of the installed HVAC systems. As such, this table presents the following parameters for each space:

- A. Room Designation.
- B. Activity for which the room is used.
- C. Floor area for the room.
- D. Maximum number of occupants that the room will seat (this information was obtained from the Vice-Principals Office).
- E. The supply air flowrate CFM (cubic feet per minute). Specified by the designer.
- F. The exhaust air flowrate CFM (cubic feet per minute). Specified by the designer.
- G. The measured supply air flowrate CFM before the institution of HVAC remediation program.
- H. The measured exhaust flowrate CFM before the institution of HVAC remediation program.
- I. The HVAC unit number.
- J. The exhaust unit number.
- K. The presence of a rug installed in the room (a check designates that a rug is in the room).
- L. A qualitative rating of the room condition. These ratings are a summation of room problems identified and reported.

- M. The observed condition of the HVAC units air filter during the before remediation inspection.
- N. The result of a damper operation test conducted during the before remediation inspection.
- O. A qualitative rating of air mixing in the spaces serviced by unit ventilators as determined using a air current Draeger tube. For purposes of this rating, the following rating numbers were applied:
 - 0. Designates that mixing was adequate.
 - 1. Designates that mixing was not as good as it could be.
 - 2. Designates that mixing in the space was stagnant.
 - 3. Designates that mixing in the space was very stagnant.
- P. Lists other comments recorded by the inspection team that are not contained in any of the listed categories.

TABLE B-1 ROOM CHARACTERISTICS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1																
2																
3																
4																
5							Before	Before								
6					Supply	Exhaust	Measured	Measured	HVAC	Exhaust	Rug	Room			UV	
7	Room	Activity	Area	Max	CFM	CFM	Supply	Exhaust	Unit	Unit	in	Condition	Filter	Damper	Mixing	
8				Occ	Design	Design	CFM	CFM	#	#	Room	Rating	Condition	Operation	Rating	Comments
9	A000-C	Corridor	4,340	N/A	1520	600	328	0	RT3	RT3	0	0	Clean, SM	OK		Coil & Drain Pan Dirty.
10	A001	BAND	1,273	10	2845	2480	1800	600	RT3	RT3	0	2	Clean, SM	OK		Coil & Drain Pan Dirty.
11	A001	BAND	1,273	10	2200	2000	1064	1140	RT3	RT3	0	2	Clean, SM	OK		Coil & Drain Pan Dirty.
12	A002	Corral Room	1,352	28	765	1855	620	850	RT3	RT3	0	2	Clean, SM	OK		Coil & Drain Pan Dirty.
13	A003	BAND (STORAGE)	168	7	1170	710	170	160	RT3	RT3	0	2	Clean, SM	OK		Coil & Drain Pan Dirty.
14	A004	OFFICES (ARTS)	1,888	7	1875	1685	690	660	RT3	RT3	0	0	Clean, SM	OK		Coil & Drain Pan Dirty.
15	A005	OFFICES (ARTS)	355	4	390	350	250	170	RT3	RT3	0	0	Clean, SM	OK		Coil & Drain Pan Dirty.
16	A006/A007	Office/Drama	2,050	23	3200	2870	1300	1300	RT3	RT3	0	0	Clean, SM	OK		Coil & Drain Pan Dirty.
17	A008	Class Room	704	25	920	825	440	580	RT3	RT3	✓	0	Clean, SM	OK		Coil & Drain Pan Dirty.
18	A009	PIANO LAB	1,104	29	1125	1000	630	420	RT3	RT3	✓	0	Clean, SM	OK		Coil & Drain Pan Dirty.
19	A010	DANCE STUDIO	1,080	19	1120	1000	450	680	RT3	RT3	0	0	Clean, SM	OK		Coil & Drain Pan Dirty.
20	A100-C	Corridor	5,035	N/A	3575	2030	2119	826	RT4	RT4	0	0	OK	OK		Coil & Drain Pan Dirty, VAV System.
21	A101	Class Room	800	19	750	325	420	186	UV	EF4	0	0	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
22	A102	Class Room	775	23	750	325	460	94	UV	EF4	0	0	Clean		2	No Control Air.
23	A103/104	OFFICE	713	1	1000	800	280	0	UV	EF4	✓	2	Clean	Inoperative	3	No Control Air.
24	A105	OFFICE	570	10	570	515	470	120	RT5	RT5	✓	2	Clean	Inoperative	2	Limited Damper Movement.
25	A106	TELEVISION LAB	530	3	4950	4240	3560	3140	RT18	RT18	✓	2	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
26	A107	OFFICES	555	26	560	520	350	230	RT3	RT3	✓	2	Clean, SM	OK		Coil & Drain Pan Dirty.
27	A108	Class Room	725	24	750	325	520	147	UV	EF14	✓	1	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
28	A109	Class Room	763	10	750	325	420	135	UV	EF14	✓	1	Dirty	Inoperative	2	
29	A110	Class Room	763	16	750	325	540	467	UV	EF14	✓	1	Clean	100% Recirc	2	No Control Air, Unit very dirty
30	A200-C	Corridor	4,350	N/A	2190	450	1115	445	RT5	RT5	0	0	Clean	100% recirc	0	No Control Air, Unit very dirty
31	A201	Class Room	735	32	750	325	440	100	UV	EF14	✓	0	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
32	A202	CHEM LAB	465	12	1000	450	590	115	UV	EF4	0	0	Clean	100% recirc	3	No Control Air, Unit very dirty, Fan not operable
33	A202	CHEM LAB	465	11	1000	450	390	115	UV	EF4	0	0	New	100% recirc	3	No Control Air
34	A203	CHEM LAB	1,418	11	1000	540	270	85	UV	EF4	0	0	Clean	100% recirc	3	No Control Air
35	A203	CHEM LAB	1,418	10	1000	540	270	85	UV	EF4	0	0	Dirty	100% recirc	3	No Control Air
36	A204	CHEM LAB	616	10	1000	450	570	90	UV	EF4	0	0	Dirty	100% recirc	3	No Control Air
37	A204	CHEM LAB	616	10	1000	450	570	90	UV	EF4	0	0	Wing Filtr	100% recirc	3	No Control Air
38	A205	Class Room	370	10	500	200	440	72	UV	EF4	✓	1	Dirty	100% recirc	3	No Control Air.
39	A206	FAC LOUNGE	490	20	500	450	250	150	RT5	RT5	✓	1	Clean	100% recirc	2	
40	A207	Class Room	456	19	460	415	314	370	RT5	RT5	✓	0	Dirty	Open		Coil & Drain Pan Dirty, Belt Loose
41	A207A	OFFICE	390	3	200	380	210	350	RT5	RT5	✓	0	Dirty	Open		Coil & Drain Pan Dirty, Belt Loose
42	A208	Class Room	605	10	560	505	360	200	RT5	RT5	✓	0	Dirty	Open		Coil & Drain Pan Dirty, Belt Loose
43	A209	OFFICE (VICE PRINCIPAL)	380	12	350	325	200	290	RT5	RT5	0	0	Dirty	Open		Coil & Drain Pan Dirty, Belt Loose
44	A210	OFFICE	416	6	250	225	0		RT5	RT5	✓	3	Dirty	Open		Coil & Drain Pan Dirty, Belt Loose
45	A211	Class Room	355	5	500	200	310	140	UV	EF14	✓	3	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
46	A212	Class Room	740	23	750	325	375	447	UV	EF14	✓	1	0	100% recirc	0	Fumes From Street.
47	A213	Class Room	299	12	350	325	200	210	RT5	RT5	0	0	Dirty	0	2	No Control Air.
48	A214	LANGUAGE LAB	758	30	500	325	380	282	UV	EF14	✓	1	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
49	A215	Class Room	735	37	740	675	420	510	RT5	RT5	✓	0	Dirty	100% recirc	2	No Control Air, Continuous Stench.
50	A216	Class Room	770	25	750	325	370	265	UV	EF14	✓	0	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
51	A217	LANGUAGE LAB	1,042	20	1000	450	590	342	UV	EF14	✓	2	0	100% recirc	0	
52	A218	LANGUAGE LAB	1,050	40	1020	860	625	485	RT5	RT5	✓	0	New	0	2	
53	A219	Class Room	365	13	500	200	350	182	UV	EF14	✓	0	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
54	A220	HUMANITIES RESOURCES	1,901	5	1920	1620	770	820	RT5	RT5	✓	0	Dirty	OK	2	
55	A300-C	Corridor	4,230	N/A	1250	0	800	0	RT6	RT6	0	0	OK, SM	OK		
56	A301	DRAFTING LAB	215	5	500	233	420	100	UV	EF8	0	0	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
57	A301	DRAFTING LAB	288	5	500	233	420	100	UV	EF40	0	0	Dirty	OK	2	Inside Damper Inopp on Low.
58	A301	DRAFTING LAB	1,323	5	500	233	420	100	UV	EF8	0	0	0	OK		
59	A302	ARTS LAB	294	10	500	225	550	55	UV	EF8	0	1	Dirty	0	2	
60	A302	ARTS LAB	1,058	10	500	225	470	55	UV	EF8	0	1	0	OK	0	
61	A303	OFFICE	207	4	200	180	130	70	RT6	RT6	✓	0	0	0	0	
62	A304	OFFICE	207	4	200	180	200	50	RT6	RT6	✓	0	OK, SM	OK		
63	A305	ARTS LAB	1,446	15	1500	450	800	140	UV	EF8	0	1	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
64	A306	Class Room	1,135	21	1500	450	850	168	UV	EF8	0	1	Dirty	0	2	
65	A307	Class Room	1,196	24	1325	1280	1090	650	RT6	RT6	0	1	Clean	0	2	
66	A308	COMPUTER LAB	1,224	30	1325	1280	810	540	RT6	RT6	0	1	OK, SM	OK		
67	A309	ARTS LAB	1,202	24	2000	329	650	162	UV	EF8	0	0	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On

TABLE B-1 ROOM CHARACTERISTICS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1																
2																
3																
4							Before	Before								
5						Supply	Exhaust	Measured	Measured	HVAC	Exhaust	Rug	Room			UV
6				Max		CFM	CFM	Supply	Exhaust	Unit	Unit	in	Condition	Filter	Damper	Mixing
7	Room	Activity	Area	Occ	Design	Design	CFM	CFM	CFM	#	#	Room	Rating	Condition	Operation	Rating
8																Comments
68	A310	OFFICE	338	5	500	200	420	75	UV	EF8	✓	2	Clean	OK		0
69	A311	STORAGE	442	2	460	415	140	95	RT6	RT6	0	0	Clean	OK		2
70	A312	PHOTO LAB	1,148	5	1005	810	740	200	RT6/EF12	RT6/EF12	0	0	OK, SM	OK		0
71	A313	Class Room	377	17	750	200	540	68	UV	EF14	✓	0	Dirty	OK		0
72	A314	GRAPHIC ARTS	3,916	6	9660	7240	2690	3130	RT7/EF13	RT7/EF13	✓	0	Dirty	OK		0
73	A315	Class Room	613	23	730	630	760	520	RT6	RT6	✓	2	OK, SM	OK		0
74	A316	Class Room	990	26	750	325	500	50	UV	EF8	0	1	Dirty	OK		0
75	A317	Class Room	713	24	960	860	420	700	RT6	RT6	✓	1	Dirty	Not Operable		2
76	A318	Class Room	858	7	700	630	420	790	RT6	RT6	✓	0	OK, SM	OK		0
77	R100-C	Corridor	9,775	N/A	0	0	1180	0	RT13	RT13	0	0	Clean	OK		0
78	R200-C	Corridor	12,300	N/A	0	0	470	0	RT13	RT13	0	0	Clean	OK		0
79	A400-C	Class Room	5,630	N/A	500	0	800	0	UV	N/A	✓	0	Dirty	OK		0
80	Main Office	Main Office	876	10	1545	1065	530	630	RT16	RT16	✓	3	Clean	OK		0
81	MOOR	Main Off Conference Room	325	10	450	550	170	110	RT16	RT16	✓	3	Clean	OK		0
82	No Dinn	North Dining Room	0	0	18000	10000	0	13550	RT12	RT12	✓	3	Clean	OK		0
83	Prin Off	Principal's Office	313	6	1240	1115	430	250	RT16	RT16	✓	3	Clean	OK		0
84	R-Health	Rindge Health Ctr	2,775	0	0	0	4250	3000	New Units	New Units	✓	3	#N/A	#N/A		#N/A
85	R101	CR/KITCHEN LAB	572	15	530	0	220	hood	RT1	RT1	0	0	Clean	OK		0
86	R102	KITCHEN	6,162	0	11100	10715	5100	hood	RT13/EF35	RT13/EF35	0	0	Clean	OK		0
87	R106	MAINTENANCE STORAGE	1,695	0	5360	5760	Not Meas	Not Meas	HV-6 & 7	HV-6 & 7	0	0	#N/A	#N/A		#N/A
88	R107	CARP LAB	5,478	0	17000	13600	10340	7540	HV-5	HV-5	0	0	#N/A	#N/A		#N/A
89	R109	ELECTRONIC LAB/ROBORU	2,130	45	2500	2565	1240	1150	RT17/EF47	RT17/EF47	0	0	Clean	OK		0
90	R110	OFFICE	744	8	1230	1110	cga	350	RT13	RT13	✓	3	Clean	OK		0
91	R111 bank	Bank	456	5	300	270	0	0	RT13	RT13	✓	0	Clean	OK		0
92	R111 storage	STORAGE	456	N/A	300	270	420	200	RT13	RT13	✓	0	Clean	OK		0
93	R113	Class Room	720	21	750	325	230	150	UV	EF24	✓	2	Dirty	OK		0
94	R114	Class Room	480	12	500	200	455	279	UV	EF24	✓	2	Dirty	Not Operable		3
95	R115	Class Room	732	21	750	325	400	290	UV	EF24	✓	2	Dirty	OK		1
96	R116	Trophy Room	744	25	900	810	570	500	RT9	RT9	✓	1	Dirty	OK		0
97	R117	Computer Room	816	19	1050	945	995	440	RT9	RT9	✓	1	Dirty	OK		0
98	R118	Security Room	240	8	210	200	50	50	RT9	RT9	0	0	Dirty	OK		0
99	R119	COMB LAB	600	20	750	675	590	430	RT17	RT17	0	0	Clean	OK		0
100	R120	Class Room	630	15	750	675	760	540	RT17	RT17	✓	0	Clean	OK		0
101	R121	OFFICE	315	8	300	270	340	120	RT17	RT17	0	0	Clean	OK		0
102	R122	Electricity Lab Office	187	8	185	165	70	130	RT17	RT17	0	0	Clean	OK		0
103	R123	Electricity Lab	3,480	35	10600	8480	6110	7305	HV-4	HV-4	0	0	#N/A	#N/A		#N/A
104	R126	Machine Shop	2,059	35	13000	10400	0	0	HV-3	HV-3	0	0	#N/A	#N/A		#N/A
105	R128	Wood Working Shop	2,052	10	6200	5990	0	0	HV-2	HV-2	0	0	#N/A	#N/A		#N/A
106	R129	NURSERY	1,080	15	750	325	390	110	UV	EF18	✓	0	Dirty	OK		0
107	R130	Day Care	1,968	15	1250	325	620	210	UV	EF47	✓	0	Dirty	Not Operable		2
108	R131	Metal Fab Shop	3,816	18	10200	8200	3340	2575	HV-1	HV-1	0	0	Dirty	OK		3
109	R132	OFFICE	352	6	345	310	280	300	RT9	RT9	0	0	Dirty	OK		0
110	R133	OFFICE	528	4	445	395	375	255	RT9	RT9	✓	0	Dirty	OK		0
111	R134	OFFICE	153	1	155	140	180	120	RT9	RT9	✓	0	Dirty	OK		0
112	R135	Office	128	6	135	120	100	50	RT9	RT9	✓	1	Dirty	OK		0
113	R136	Vocational Training	816	6	750	325	OFF	69	UV	EF21	✓	1	Dirty	OK		0
114	R137	Copy Room	720	6	750	325	450	59	UV	EF21	✓	3	0	OK		0
115	R201	OFFICE	871	10	740	670	350	340	RT2	RT2	0	0	Dirty	0		3
116	R202	OFFICE	105	4	115	100	301	168	RT13	RT13	0	0	Clean	OK		0
117	R203	SCIENCE CR/LAB	143	6	185	165	168	112	RT13	RT13	0	0	Clean	OK		0
118	R204	SCIENCE CR/LAB	1,080	16	1650	1800	1730	1230	RT13	RT13	0	0	Clean	OK		0
119	R205	SCIENCE CR/LAB	1,363	21	2135	2480	1000	1250	RT13	RT13	0	0	Clean	OK		0
120	R205A	SCIENCE CR/LAB	485	4	885	800	400	460	RT13	RT13	0	0	Clean	OK		0
121	R206	SCIENCE CR/LAB	1,363	21	2130	2340	1450	774	RT13	RT13	0	0	Clean	OK		0
122	R207	OFFICE	1,080	22	1650	1800	1180	1551	RT13	RT13	0	0	Clean	OK		0
123	R209	COMPUTER LAB	1,767	15	495	445	0	0	AC2	AC2	✓	0	#N/A	#N/A		#N/A
124	R211	COMPUTER LAB	1,125	15	3825	3445	370	240	AC2	AC2	✓	0	#N/A	#N/A		#N/A
125	R212	Class Room	810	20	1460	1350	990	380	RT17	RT17	0	0	Clean	OK		0
126	R213	Class Room	638	6	750	325	370	0	UV	EF48	✓	1	Dirty	OK		0
127	R214	Class Room	756	29	750	325	300	0	UV	EF48	✓	1	0	OK		0

TABLE B-1 ROOM CHARACTERISTICS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1																
2																
3																
4																
5																
6					Supply	Exhaust	Before	Before	HVAC	Exhaust	Rug	Room			UV	
7	Room	Activity	Area	Max	CFM	CFM	Measured	Measured	Unit	Unit	in	Condition	Filter	Damper	Mixing	
8				Occ	Design	Design	Supply	Exhaust	#	#	Room	Rating	Condition	Operation	Rating	Comments
128	R215	Class Room	812	26	750	325	310	0	UV	EF49	✓	2	0	0	0	0
129	R216	Class Room	860	28	750	325	240	0	UV	EF49	✓	2	0	0	0	0
130	R217	Class Room	705	33	750	325	380	0	UV	EF49	✓	2	0	0	0	0
131	R218	Class Room	685	31	750	325	390	0	UV	EF49	✓	2	0	0	0	0
132	R219	Office	810	22	750	405	??	0	UV	EF49	✓	1	0	0	0	0
133	R220	Class Room	720	23	750	325	380	0	UV	EF49	✓	1	0	0	0	0
134	R221	Class Room	660	23	500	200	360	50	UV	EF49	✓	1	0	0	0	0
135	R222	School Committee Meeting	1,418	30	1800	1780	1070	900	RT17	RT17	✓	1	0	0	0	0
136	R222A	Pantry	263	10	215	295	350	280	RT17/EF49	RT17/EF49	0	0	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
137	R223	OFFICE	732	16	700	630	450	700	RT13	RT13	✓	2	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
138	R224	Radio Station	504	12	500	450	0	0	RT13	RT13	✓	2	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
139	R225	Class Room	240	12	200	180	130	290	RT13	RT13	✓	1	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
140	R226	Class Room	447	16	500	200	160	220	UV	EF40	✓	1	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
141	R227	Class Room	458	12	500	200	480	130	UV	EF40	✓	2	Dirty	0	3	No Control Air. Very Stagnant.
142	R228	Class Room	708	25	750	325	460	140	UV	EF40	✓	2	Dirty	Not Operable	0	Filter Deflected.
143	R229	Class Room	744	23	750	325	320	54	UV	EF40	✓	2	Dirty	OK	3	
144	R230	Class Room	806	31	750	325	460	160	UV	EF24	✓	3	Dirty	OK	0	0
145	R231	Class Room	416	7	500	200	460	110	UV	EF24	✓	0	Dirty	OK	2	0
146	R232	Class Room	416	6	500	200	540	190	UV	EF24	✓	0	Dirty	OK	0	0
147	R233	Class Room	780	21	750	325	500	360	UV	EF24	✓	1	Dirty	OK	3	Birds Nest, Filter Deflected.
148	R234	Class Room	504	12	500	325	520	0	UV	EF25	✓	3	Dirty	OK	2	Lighthead, Nose & Throat Irritation.
149	R235	Class Room	744	23	750	325	360	0	UV	EF25	✓	3	Dirty	OK	2	Noisy Fan. Fresh air damper does not close.
150	R236	OFFICE	480	25	500	200	700	50	UV	EF25	✓	3	Dirty	OK	2	Very Dirty System.
151	R237	OFFICE	288	4	160	145	40	0	RT9	RT9	✓	1	Dirty	OK	0	0
152	R238	COMPUTER LAB	450	10	680	600	550	550	RT17	RT17	✓	1	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
153	R239	CR (READING LAB)	1,007	30	750	325	400	0	UV	EF45	✓	0	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
154	R239	CR (READING LAB)	1,022	14	750	325	400	0	UV	EF45	✓	0	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
155	R240	Class Room	344	18	500	200	250	0	UV	EF45	✓	2	0	OK	0	Pipes Leak.
156	R240	Class Room	484	15	500	200	250	0	UV	EF45	✓	2	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
157	R241	Career Resources	732	15	750	287.5	550	0	UV	EF40	✓	1	0	0	0	0
158	R241	Career Resources	732	16	1000	287.5	550	0	UV	EF46	✓	1	0	0	0	0
159	R242/243	TYPING LAB	1,449	28	1250	575	470	460	UV	EF46	✓	2	0	0	0	0
160	R244	Class Room	1,220	29	750	325	370	300	UV	EF46	✓	2	0	0	0	0
161	R245	Office	1,022	2	750	325	600	240	UV	EF46	✓	1	Dirty	0	3	0
162	R246	Class Room	1,083	37	750	325	400	240	UV	EF46	✓	2	0	OK	0	0
163	R247	Class Room	854	22	750	325	410	0	UV	EF45	✓	1	Dirty	0	3	Very Stagnant.
164	R248	TYPING LAB	686	28	750	325	430	0	UV	EF45	✓	0	Dirty	OK	3	Very Stagnant.
165	R249	TYPING LAB	1,007	20	750	325	390	0	UV	EF45	✓	0	Dirty	OK	3	Very Stagnant.
166	R250	Typing Lab	976	32	1730	1550	1200	640	RT17	RT17	✓	0	Dirty	OK	3	Very Stagnant.
167	R251	Class Room	580	24	750	325	540	44	UV	EF23	✓	1	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
168	R252	Class Room	754	18	750	325	440	44	UV	EF23	✓	1	Dirty	OK	3	OA Damper Inoperative. Air Bypass Coil Birds
169	R253	Class Room	717	15	860	775	760	750	RT9	RT9	✓	2	Clean	Not Operable	2	Hot & Stuffy in Warm Weather.
170	R254	Office	266	3	310	280	290	290	RT9	RT9	✓	2	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
171	R255	Clothing Lab	1,098	14	750	325	500	186	UV	EF18	0	0	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
172	R256	HOME EC	840	12	1150	450	500	280	UV	EF18	0	0	Dirty	Not Operable	2	Very Dirty Unit.
173	R257	HOME EC	840	13	1000	450	580	470	UV	EF17	0	0	0	Not Operable	0	0
174	R258	OFFICE	1,113	12	750	325	370	300	UV	EF17	✓	2	Dirty	0	2	0
175	R259	Office	266	3	310	280	110	50	RT9	RT9	✓	0	Dirty	Not Operable	2	0
176	R260	Class Room	717	29	860	775	640	640	RT9	RT9	✓	1	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
177	R261	Class Room	775	43	750	325	350	50	UV	EF21	✓	3	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
178	R262	MEDIA CTR OFFICE	682	32	750	325	540	96	UV	EF21	✓	1	Clean	Not Operable	3	0
179	R300-C	Corridor	8,300	N/A	850	250	290	0	RT9	RT9	0	0	Clean	OK	3	0
180	R301	OFFICE	868	10	1020	920	300	460	RT13/EF40	RT13/EF40	0	3	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
181	R302	OFFICE	349	11	540	480	520	380	RT13	RT13	✓	1	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
182	R303	Office	140	1	100	90	100	70	RT13	RT13	✓	0	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
183	R304	SCIENCE CRLAB	1,138	17	1540	1380	820	670	RT13	RT13	0	0	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
184	R305	SCIENCE CRLAB	1,330	20	1875	2080	1774	1730	RT13	RT13	0	1	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
185	R306	SCIENCE CRLAB	67	15	1000	1100	1180	640	RT13/EF31	RT13/EF31	0	0	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
186	R307	SCIENCE CRLAB	1,330	20	1965	2160	1490	1060	RT13	RT13	0	1	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
187	R308	Science	1,138	19	1540	1380	1620	1460	RT13	RT13	0	0	Clean	OK		Coil & Drain Pan Dirty, Belt Loose

TABLE B-1 ROOM CHARACTERISTICS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1																
2																
3																
4																
5						Supply	Exhaust	Before	Before							
6				Max	CFM	CFM	Measured	Measured	HVAC	Exhaust		Room			UV	
7	Room	Activity	Area	Occ	Design	Design	Supply	Exhaust	Unit	Unit	in	Condition	Filter	Damper	Mixing	
8							CFM	CFM	#	#	Room	Rating	Condition	Operation	Rating	Comments
188	R309	OFFICE	140	7	100	90	470	110	RT13	RT13	✓	0	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
189	R310	OFFICE	330	4	370	370	230	180	RT13	RT13	✓	1	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
190	R311	Class Room	300	11	500	200	480	87	UV	EF38	✓	2	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
191	R312	Class Room	308	31	500	200	580	130	UV	EF38	✓	3	Clean	OK	2	
192	R313	FACULTY LOUNGE	480	12	500	200	500	110	UV	EF38	✓	2	Dirty	OK	2	
193	R314	Class Room	360	8	500	200	OFF	220	UV	EF39	✓	2	Clean	OK	2	
194	R315	Class Room	372	11	500	200	520	160	UV	EF39	✓	3	Clean	OK	2	
195	R316	Class Room	960	28	750	325	500	190	UV	EF39	0	0	Dirty	OK	2	Green Dust. Filter Deflected.
196	R317	Class Room	720	49	500	325	540	150	UV	EF40	0	0	Clean	OK	2	
197	R318	Class Room	720	33	750	325	540	180	UV	EF40	✓	2	Dirty	OK	2	Potting Soil Odor.
198	R319	Class Room	329	9	500	299	270	120	UV	EF40	0	0	Dirty	OK	0	
199	R320	Class Room	353	3	500	200	520	220	UV	EF40	✓	2	Clean	OK	2	Feels Stagnant.
200	R321/2/3	OFFICE	363	3	1000	450	425	50	UV	EF37	✓	0	Dirty	OK	0	
201	R325	Class Room	960	24	750	325	625	150	UV	EF24	✓	3	0	OK	0	Can't measure uv with Alnor.
202	R326	Class Room	708	29	750	325	480	140	UV	EF24	✓	1	Dirty	0	2	Control Air Leaks.
203	R327	Class Room	705	26	750	325	500	210	UV	EF24	✓	1	Dirty	Not Operable	2	
204	R328	COMPUTER LAB	360	25	500	200	350	0	UV	EF25	✓	0	Dirty	OK	2	Dampers do not move.
205	R329	COMPUTER LAB	624	14	500	200	370	0	UV	EF25	✓	2	Dirty	Not Operable	2	
206	R330	Class Room	1,044	24	1250	445	100	0	UV	EF25	✓	2	Dirty	OK	2	Old Metal Filter Frames.
207	R331	OFFICE	240	3	310	130	250	0	UV	EF25	✓	2	Dirty	OK	3	Filter Deflected.
208	R332	OFFICE	180	2	500	200	600	50	UV	EF23	✓	0	Dirty	OK	0	
209	R333	Class Room	736	28	1000	400	400	100	UV	EF23	0	0	Clean	Dirty	0	
210	R334	Class Room	479	23	1185	1065	820	450	RT9	RT9	✓	2	Dirty	OK	2	Filter Deflected. Stagnant.
211	R335	Class Room	479	20	1100	900	780	350	RT9	RT9	✓	1	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
212	R336	Class Room	479	25	1100	900	600	580	RT9	RT9	✓	3	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
213	R337	Class Room	536	30	1215	900	700	580	RT9	RT9	✓	4	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
214	R338	OFFICE	202	10	290	260	470	550	RT9	RT9	✓	0	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
215	R339	Class Room	496	21	935	840	500	1200	RT9	RT9	✓	4	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
216	R340	Class Room	374	43	430	385	320	320	RT9	RT9	✓	4	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
217	R341	Class Room	594	30	700	630	550	380	RT9	RT9	✓	2	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
218	R342	OFFICES	374	9	430	385	520	220	RT9	RT9	✓	2	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
219	R343	Class Room	816	1	1105	980	420	335	RT10	RT10	✓	2	Clean	OK		Coil & Drain Pan Dirty, Belt Loose
220	R344	Class Room	704	17	750	325	540	50	UV	EF21	✓	4	Dirty	OK		Coil & Drain Pan Dirty, Belt Loose, Heating On
221	R400	Class Room	972	26	1000	450	560	450	UV	EF40	0	0	0	OK	0	Labeled on Sketch as R342
222	R401	COMPUTER LAB	450	11	500	200	610	180	UV	EF40	✓	1	Dirty	0	2	Low airflow.
223	R402	Class Room	975	21	750	415	580	230	UV	EF40/EF37	✓	2	Dirty	OK	2	
224	R403	Class Room	990	20	750	325	520	330	UV	EF40	0	1	0	OK	0	
225	R404	Class Room	846	20	750	260	110	220	UV	EF39	0	1	Clean	0	3	Dampers Not Operable.
226	R405	Class Room	968	25	1000	325	400	640	UV	EF38	✓	4	Clean	Not Operable	3	Dampers Not Operable.
227	R406	OFFICE	179	2	250	65	100	140	UV	EF38	✓	2	Dirty	Not Operable	3	Dampers Not Operable.
228	R407	Class Room	775	26	750	325	540	370	UV	EF39	✓	3	0	Not Operable	0	
229	R408	Class Room	513	18	500	200	520	200	UV	EF39	✓	2	Dirty	0	2	
230	R409	Class Room	550	18	500	200	600	180	UV	EF39	0	0	Clean	OK	2	
231	R410	Class Room	984	26	1000	450	OFF	320	UV	EF40	0	0	New	OK	2	Recirculation Damper Jammed.
232	R411	OFFICE	468	10	750	275	540	120	UV	EF24	✓	2	New	See Comment	0	Control air Leak.
233	R412	Class Room	552	29	500	200	500	130	UV	EF24	✓	2	Good	See Comment	0	
234	R413	Class Room	444	18	500	200	380	250	UV	EF24	✓	2	Dirty	OK	3	Recirculation Damper inoperative. Unit Noisy
235	R414	Class Room	576	30	0	0	540	240	UV	EF24	✓	2	Good	OK	2	Room seems stagnant.
236	R415	Class Room	384	8	500	200	500	390	UV	EF24	✓	2	0	OK	0	
237	R416	Class Room	468	30	500	200	480	50	UV	EF25	✓	4	New	0	0	
238	R417	Class Room	720	23	750	325	540	50	UV	EF25	✓	3	Dirty	OK	2	Filter Deflected.
239	R418	Class Room	300	9	500	200	600	50	UV	EF25	✓	3	0	OK	2	
240	R419	Class Room	300	8	500	200	450	50	UV	EF25	✓	1	Clean	0	0	
241	R420	Class Room	336	16	500	200	380	50	UV	EF25	✓	2	New	OK	0	Dampers Inoperative.
242	R421	Class Room	936	31	1000	450	680	200	UV	EF23	0	3	Good	Inoperative	2	
243	R422	Class Room	349	39	500	200	580	0	UV	EF25	✓	2	Good	OK	2	
244	R423	Class Room	379	30	500	200	580	0	UV	EF25	✓	3	Dirty	OK	0	Damper Inoperative.
245	R424	Class Room	359	28	500	200	620	50	UV	EF25	✓	3	Dirty	Inoperative	2	
246	R425	Class Room	359	29	500	200	570	0	UV	EF25	✓	3	Good	OK	0	
247	R426	OFFICE	371	24	500	200	620	150	UV	EF21	✓	2	Dirty	OK	2	Damper Inoperative

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[illegible]

Appendix C Results of HVAC Remediation Program

Inspection and measurement of the performance of the HVAC systems at CRLS showed that the airflow through these systems was far less than the airflow specified in the original HVAC system design. Part of this performance problem was attributed to the filth allowed to accumulate on the filters and coils of these systems. It was the recommendation of EHE that all filters be changed and coils cleaned. This remediation step began in August, and is currently nearing completion. The following table (Table F-1) presents the results of this remediation activity, for unit ventilators which have been cleaned and have had flows re-measured as of this date. The table also contrasts the flows before and after cleaning and filter replacement. This table presents the following parameters for each unit ventilator cleaned:

- A. Date measurement was performed on cleaned unit.
- B. Room designation.
- C. The noted position of exterior doors & windows in the space during the measurement activity.
- D. The post-cleanup supply air flow (in cubic feet per minute (CFM)).
- E. The post-cleanup return air flow in CFM.
- F. The percentage of supply airflow that was outdoor air at the time the measurement was taken. This parameter was calculated from the measured values as follows:

$$\%OA = (\text{Post-cleanup CFM} - \text{Post-return CFM}) / \text{Post-Supply CFM} * 100$$

- G. The post-cleanup percentage of nominal unit capacity. This parameter was calculated from the measured values as:

$$\text{Post-cleanup \% Capacity} = \text{Post-Supply CFM} / \text{Nominal CFM}$$

- H. The nominal flow capacity of the unit ventilator in CFM (obtained from building plans).
- I. The pre-cleanup measured supply flow in CFM.
- J. The pre-cleanup percentage of nominal unit capacity. This parameter was calculated from the measured values as:

$$\text{Pre-cleanup \% Capacity} = \text{Pre-Supply CFM} / \text{Nominal CFM} * 100\%$$

- K. The improvement of supply airflow that resulted from the cleaning and re-filtering project. This parameter was calculated as follows:

$$\% \text{ Improvement} = (\text{Post-cleanup CFM} - \text{Pre-cleanup CFM}) / \text{Pre-cleanup CFM} * 100\%$$

TABLE C-1 RESULTS OF REMEDIATION

	A	B	C	D	E	F	G	H	I	J	K
1	Date	Room #	Doors & Windows	Post-Clean Supply CFM	Post-Clean Return CFM	% OA	Post-Clean % Capacity	Nominal CFM	Pre-Cleaned Meas CFM	Pre-Cleaned % Capacity	Percent Improvement
2											
3	10/2/89	R113	CLOSED	600	190	68%	80%	750	230	31%	161%
4	11/22/89	R114	CLOSED	540	210	61%	108%	500	455	91%	19%
5	10/2/89	R115	CLOSED	600	340	43%	80%	750	400	53%	50%
6	10/26/89	R115	CLOSED	580	310	47%	77%	750	400	53%	45%
7	10/26/89	R129	CLOSED	580	310	47%	77%	750	390	52%	49%
8	10/2/89	R130	CLOSED	680	540	21%	54%	1250	620	50%	10%
9	10/26/89	R130	CLOSED	660	560	15%	53%	1250	620	50%	6%
10	10/26/89	R200 Corridor	CLOSED	540	270	50%	72%	750	450	60%	20%
11	10/25/89	R213	CLOSED	600	300	50%	80%	750	370	49%	62%
12	10/25/89	R214	CLOSED	500	200	60%	67%	750	300	40%	67%
13	11/22/89	R215	CLOSED	600	150	75%	80%	750	310	41%	94%
14	11/14/89	R216	CLOSED	540	220	59%	72%	750	240	32%	125%
15	11/14/89	R217	CLOSED	600	300	50%	80%	750	380	51%	58%
16	11/14/89	R220	CLOSED	600	340	43%	80%	750	380	51%	58%
17	11/14/89	R221	CLOSED	530	310	42%	106%	500	360	72%	47%
18	10/26/89	R226		200	75	63%	40%	500	160	32%	25%
19	10/26/89	R228	CLOSED	550	180	67%	73%	750	460	61%	20%
20	10/25/89	R229	CLOSED	570	230	60%	76%	750	320	43%	78%
21	10/26/89	R229	CLOSED	570	230	60%	76%	750	320	43%	78%
22	10/26/89	R230	CLOSED	610	270	56%	81%	750	460	61%	33%
23	10/26/89	R231	CLOSED	550	260	53%	110%	500	460	92%	20%
24	10/26/89	R232	CLOSED	620	310	50%	124%	500	540	108%	15%
25	10/26/89	R233	CLOSED	630	340	46%	84%	750	500	67%	26%
26	11/14/89	R235	CLOSED	540	230	57%	72%	750	360	48%	50%
27	11/14/89	R239	CLOSED	620	400	35%	83%	750	400	53%	55%
28	11/14/89	R240	CLOSED	600	240	60%	120%	500	250	50%	140%
29	11/14/89	R244	CLOSED	620	390	37%	83%	750	370	49%	68%
30	11/14/89	R247	CLOSED	500	230	54%	67%	750	410	55%	22%
31	11/14/89	R248	CLOSED	510	220	57%	68%	750	430	57%	19%
32	11/14/89	R249	CLOSED	560	260	54%	75%	750	390	52%	44%
33	10/26/89	R251	CLOSED	640	190	70%	85%	750	540	72%	19%
34	10/26/89	R252	CLOSED	620	190	69%	83%	750	440	59%	41%
35	11/14/89	R255	CLOSED	590	260	56%	79%	750	500	67%	18%
36	11/14/89	R256	CLOSED	700	410	41%	61%	1150	500	43%	40%
37	11/14/89	R257	CLOSED	710	600	15%	71%	1000	580	58%	22%
38	11/14/89	R257 AND	CLOSED	350			35%	1000	580	58%	-40%
39	11/14/89	R261	CLOSED	520	380	27%	69%	750	350	47%	49%

TABLE C-1 RESULTS OF REMEDIATION

	A	B	C	D	E	F	G	H	I	J	K
1	Date	Room #	Doors & Windows	Post-Clean Supply CFM	Post-Clean Return CFM	% OA	Post-Clean % Capacity	Nominal CFM	Pre-Cleaned Meas CFM	Pre-Cleaned % Capacity	Percent Improvement
2											
40	10/26/89	R262	CLOSED	600	210	65%	80%	750	540	72%	11%
41	11/14/89	R295	CLOSED	610	290	52%	81%	750	540	72%	13%
42	10/18/89	R311	CLOSED	610	500	18%	122%	500	480	96%	27%
43	11/14/89	R312	CLOSED	600	500	17%	120%	500	580	116%	3%
44	10/18/89	R313		660	400	39%	132%	500	500	100%	32%
45	11/14/89	R314	CLOSED	580	210	64%	116%	500	OFF		
46	11/14/89	R315	CLOSED	600	460	23%	120%	500	520	104%	15%
47	10/18/89	R316		610	270	56%	81%	750	500	67%	22%
48	10/18/89	R317		680	500	26%	136%	500	540	108%	26%
49	10/18/89	R318		600	310	48%	80%	750	540	72%	11%
50	11/14/89	R319	CLOSED	500	360	28%	100%	500	270	54%	85%
51	10/18/89	R320		620	280	55%	124%	500	520	104%	19%
52	11/22/90	R321	CLOSED	230			46%	500	520	104%	-56%
53	11/22/89	R323	CLOSED	230			23%	1000	425	43%	-46%
54	10/18/89	R325		720	580	19%	96%	750	625	83%	15%
55	10/18/89	R326		560	300	46%	75%	750	480	64%	17%
56	10/18/89	R327		600	450	25%	80%	750	500	67%	20%
57	10/25/89	R328	CLOSED	620	310	50%	124%	500	350	70%	77%
58	11/22/89	R329	CLOSED	600	180	70%	120%	500	370	74%	62%
59	11/22/89	R330	CLOSED, SEE NOTES	780	640	18%	62%	1250	100	8%	680%
60	11/22/89	R331	CLOSED	340			110%	310	250	81%	36%
61	10/18/89	R332		660	330	50%	132%	500	600	120%	10%
62	10/25/89	R333	CLOSED	630	170	73%	63%	1000	400	40%	58%
63	10/18/89	R344	CLOSED	600	160	73%	80%	750	540	72%	11%
64	10/2/89	R400	CLOSED	720	300	58%	72%	1000	560	56%	29%
65	10/2/89	R400 Corridor	NA/HALLWAY	640	260	59%	64%	1000	560	56%	14%
66	10/2/89	R401	CLOSED	620	410	34%	124%	500	610	122%	2%
67	10/2/89	R402	CLOSED	620	190	69%	83%	750	580	77%	7%
68	10/2/89	R403	CLOSED	560	430	23%	75%	750	520	69%	8%
69	10/2/89	R404	CLOSED, SEE NOTES	540	510	6%	72%	750	110	15%	391%
70	10/2/89	R405	CLOSED, SEE NOTES	520	170	67%	52%	1000	400	40%	30%
71	10/2/89	R407	CLOSED	620	310	50%	83%	750	540	72%	15%
72	10/2/89	R408	CLOSED	600	230	62%	120%	500	520	104%	15%
73	10/18/89	R409	CLOSED	600	370	38%	120%	500	600	120%	0%
74	11/22/89	R410	CLOSED	660	210	68%	66%	1000	OFF		
75	10/2/89	R412	CLOSED	740	320	57%	148%	500	500	100%	48%
76	10/2/89	R413	CLOSED	660	220	67%	132%	500	380	76%	74%

TABLE C-1 RESULTS OF REMEDIATION

	A	B	C	D	E	F	G	H	I	J	K
1	Date	Room #	Doors & Windows	Post-Clean	Post-Clean	% OA	Post-Clean	Nominal	Pre-Cleaned	Pre-Cleaned	Percent
2				Supply CFM	Return CFM		% Capacity	CFM	Meas CFM	% Capacity	Improvement
77	10/2/89	R414	CLOSED	620	210	66%			540		15%
78	10/18/89	R415	CLOSED	600	520	13%	120%	500	500	100%	20%
79	11/22/89	R416	CLOSED	480	150	69%	96%	500	480	96%	0%
80	11/22/89	R417	CLOSED	540	310	43%	72%	750	540	72%	0%
81	11/22/89	R418	CLOSED	600	250	58%	120%	500	600	120%	0%
82	11/22/89	R419	CLOSED	640	500	22%	128%	500	450	90%	42%
83	11/22/89	R420	CLOSED	620	240	61%	124%	500	380	76%	63%
84	11/22/89	R421	CLOSED	820	290	65%	82%	1000	680	68%	21%
85	10/2/89	R422	CLOSED	620	380	39%	124%	500	580	116%	7%
86	10/18/89	R423	CLOSED	600	280	53%	120%	500	580	116%	3%
87	11/22/89	R424	CLOSED	610	270	56%	122%	500	620	124%	-2%
88	11/22/89	R425	CLOSED	570	290	49%	114%	500	570	114%	0%
89	10/18/89	R426	CLOSED	680	380	44%	136%	500	620	124%	10%
90	11/27/89	R501	CLOSED	540	180	67%	72%	750	600	80%	-10%
91	11/27/89	R503	CLOSED	1050	500	52%	140%	750	780	104%	35%
92	11/27/89	R504	CLOSED	620	270	56%	83%	750	540	72%	15%
93	11/27/89	R506	CLOSED	580	280	52%	77%	750	580	77%	0%
94	11/27/89	R507	CLOSED	600	280	53%	80%	750	580	77%	3%
95	11/27/89	R509	CLOSED	540	230	57%	108%	500	560	112%	-4%
96	11/27/89	R510	CLOSED	600	280	53%	120%	500	560	112%	7%
97	11/27/89	R512	CLOSED	580	425	27%	77%	750	600	80%	-3%
98	11/27/89	R513	CLOSED	560	420	25%	75%	750	410	55%	37%
99											
100			Maximum	1050	640	75%	148%	1250	780	124%	680%
101			Minimum	200	75	6%	23%	310	100	8%	-56%
102											
103			Average	591	312	49%	90%	697	470	72%	40%
104			Standard Deviation	106	116	17%	27%	195	125	27%	84%

Appendix D Complaint Correlation

An integral part of the air quality evaluation and remediation process is the monitoring of subjective responses from the building occupants. While complaint documentation and response has been an ongoing part of building operations since approximately 1983, the complaint form used for this purpose, does not lend itself well to correlation and identification of air quality problems. To meet this need, a new complaint correlation form was developed and distributed to faculty and staff at the beginning of the fall 1989 academic term. Figure D-1 is a copy of this complaint form. This form is printed on a carbonless triplicate form. One copy is retained by the complaint originator, one copy goes to the Assistant Principals Office, and the third copy is sent to EHE, where it is stored for later analysis of trends.

Once EHE receives a complaint form, an EHE on-site person visits the complaint area. The EHE person diagnoses the problem and if possible and makes appropriate adjustments to eliminate the complaint. If the problem is one that cannot be immediately resolved, the EHE person develops the appropriate design and work orders for outside contractors to resolve the problem.

Table D-1 is a compilation of complaints received as of the date of this report.

CAMBRIDGE RINDGE & LATIN COMPLAINT QUESTIONNAIRE

Complainant's Name (Optional): _____

Location of Complaint: Room: Area:

Time and Date of Complaint: Date: / / Time : AM
PM

Nature of Complaint: (Check applicable boxes)

Eye Irritation ☐

Contact Lenses: ☐

Nose Irritation ☐

Throat Irritation ☐

Dizziness ☐

Headache ☐

Nausea ☐

Respiratory Response ☐ (please describe): _____

Space is Stuffy ☐

Space has odor ☐

Space is too Warm ☐

Space is too Cold ☐

Lighting is Inadequate ☐

Light Flickers ☐

Lighting Quality is a source of Irritation ☐

Noise in space is irritating ☐

Other Complaint: ☐ (please describe): _____

TABLE D-1 COMPLAINT FORM RESPONSES

Loc Room	Date of Complaint	Eye Irrit.	Contact Lenses	Nose Irrit.	Throat Irrit.	Nature of Complaint			Respiratory Response	Space is Stuffy	Space has Odor	Space Too Warm	Space Too Cold	Lighting Inadequate	Light Flickers	Light qual. is a source of Irritation	Noise in space is Irritating	Other Complaints	Total
A005	9/20/89 - all day							1	1									1	4
A006	9/20/89 - am hours								1			1							2
A010	9/22/89 - am hours									1		1						1	3
A103	10/31/89 - 1:30pm	1	1					1	1			1				1		1	7
A103																1		1	3
A103/Arts	9/22/89 - 1:00 pm					1		1	1			1				1			5
A105	9/20/89 - 9:34am			1					1	1	1	1							4
A206	11/7/89 - 9:50am									1		1						1	3
A207	9/19/89 - 8:30 am										1							1	2
A207A	10/28/89 - 11:45 am												1					1	1
A208	10/11/89 - 11:39am							1	1			1		1				1	5
A212	9/11/89 - all day	1		1	1				1	1								1	6
A217	10/11/89 -												1					1	2
A218	10/28/89 - 11:45am												1					1	1
A220	10/16/89 -							1											1
A220	10/20/89 - 2:00pm									1		1							2
A220	10/28/89 - 8:00am											1			1			1	3
A220	10/6/89 - 10:00am											1						1	2
A220	11/8/89 - 2:30pm											1						1	2
A220	9/15/89 - 10:00am	1			1	1										1			4
A220	9/18/89 - 1:00pm				1														1
A221	11/16/89 - all day												1					1	2
A254	9/19/89 - 9:00am	1	1	1	1	1	1	1	1				1					1	9
A260	9/14/89 - 2:25pm	1		1				1										1	3
A306	9/14/89 - all day		1	1	1					1		1						1	6
A312	9/18/89 -													1		1		1	3
A318	9/14/89 - 3:00pm					1		1										1	2
A318	9/15/89 -				1			1		1			1					1	5
A318	9/28/89 - 3:00pm				1					1								1	3
AD Office	9/18/89 - 4:10pm							1										1	3
Basement	9/28/89 - all day							1		1								1	3
boys locker R	9/22/89 - 10:07am	1	1	1	1	1	1	1	1	1								1	10
Compt. Room	10/4/89 - 9:40am																	1	1
Drama	10/2/89 - 8:00am										1							1	2
drama	9/14/89 - 8:30am									1					1			1	3
Drama	9/20/89 - 10:00am					1				1		1						1	4
Kitchen	9/14/89 - am hours	1		1		1				1		1							5
M Cafe	9/25/89 - 9:50am																	1	1
M Office	9/26/89 - 12:40pm												1						1
M office																			1
Main office	9/26/89 - 12:30pm	1		1	1	1						1	1				1	3	6
Main office	9/29/89 - 9:00am	1			1								1			1			2
O near Weigh	9/22/89 - 10:07am	1	1			1	1	1	1	1									6
office	9/14/89 - 3:30pm			1	1	1	1	1	1			1		1				1	10
Phs. Ed.	9/22/89 - 4:10pm							1	1									1	3
Phys Ed.	11/7/89 - am	1		1	1	1	1	1	1	1			1	1			1	1	11
R102	9/14/89 - 1:00pm					1	1	1		1	1	1		1				1	7
R102	9/21/89 - All day									1								1	3
R108	10/10/89 - am hours												1					1	2
R108	11/20/89 - 8:30am												1					1	2
R109	9/15/89 - 8:30am		1					1										1	3
R110	10/3/89 - 11:10am									1		1							2
R110	10/3/89 - 11:00am					1				1									3
R110	9/19/89 - 8:20am				1	1	1			1		1							5
R110	9/19/89 - 8:30am					1	1			1		1							4
R110	9/21/89 - 9:00am									1								1	3
R110	9/21/89 - 9:00am						1			1									3
R113	9/15/89 - 8:10am						1	1				1						1	4
R114	9/12/89 -	1		1	1	1	1	1	1	1									7
R114	9/14/89 - 1:00pm					1				1		1						1	4

TABLE D-1 COMPLAINT FORM RESPONSES

Loc	Date	Eye	Contact	Nose	Throat	Nature of Complaint			Respiratory	Space is	Space has	Space	Space	Lighting	Light	Light qual. i	Noise in	Other	Total
Room	of Complaint	Irrit.	Lenses	Irrit.	Irrit.	Dizziness	Headache	Nausea	Response	Stuffy	Odor	Too Warm	Too Cold	Inadequate	Flickers	a source of	space is	Complaints	
R118	10/24/89 -	1		1	1	1				1		1		1		Irritation	Irritating	1	8
R118	9/14/89 -	1		1		1			1	1		1		1					7
R118 S office	9/25/89 - 9:00am	1		1	1	1				1		1		1				1	8
R119	9/15/89 - 9:45am			1		1			1		1		1	1				1	7
R121	10/10/89 - all day												1						1
R121	10/13/89 - all day												1						1
R121	10/5/89 - all day												1						1
R125	9/26/89 - 10:00am										1							1	2
R128	10/31/89 - all day												1					1	2
R128	9/18/89 - 8:30am												1	1				1	3
R128													1		1			1	3
R203	10/4/89 - all day									1		1						1	3
R204	10/3/89 - 1:30pm					1	1			1		1						1	5
R204	9/18/89 - 8:30am								1										1
R205	10/6/89 - 7:30 am									1		1							3
R206/R204	10/18/89 - 8:30am			1	1	1			1		1							1	5
R215	9/18/89 - am hours									1		1						1	3
R217	10/5/89 - 11:45am	1					1			1		1						1	5
R218	10/10/89 - 1:45pm										1			1				1	2
R218	10/2/89 - 8:00am												1					1	2
R218	10/5/89 - 1:45pm										1		1					1	3
R218	10/5/89 - 8:15am										1		1					1	3
R218	9/14/89 - 10:00am	1				1	1			1		1							5
R218	9/28/89 - 10:00am												1						1
R218						1				1	1		1					1	5
R218													1						2
R219	9/14/89 - 9:10am									1		1						1	2
R220	9/22/89 - 9:30am	1	1			1	1		1	1		1							7
R221	10/13/89 - 10:07am	1		1							1							1	4
R221	10/25/89 - 10:10am		1	1		1	1	1		1	1							1	8
R221	10/27/89 - am			1				1		1	1							1	6
R221	9/27/89 - 10:00am			1							1							1	3
R221/R329	School Day	1			1		1		1	1	1	1						1	8
R223	10/4/89 - 8:00am									1	1	1						1	4
R223	9/18/89 - am hours									1	1							1	3
R223	9/19/89 - pm hours						1		1	1	1							1	5
R228	9/15/89 - all day			1	1	1	1			1		1							6
R228	All Day			1	1	1	1			1		1							6
R229	9/19/89 - 7:39am	1		1					1	1		1					1		8
R233	9/18/89 - 1:15pm	1		1	1				1			1						1	5
R233		1		1	1				1			1							5
R240	9/15/89 - pm hours	1	1	1	1				1	1		1		1		1		1	9
R241	10/5/89 - 12:00pm												1					1	2
R241	11/16/89 - 2:00pm								1									1	2
R241	11/3/89 - 1:25pm			1	1				1										3
R241	11/7/89 - 11:30am				1	1			1									1	4
R241	9/18/89 -				1	1				1				1	1	1			6
R241	9/27/89 - 10:50am				1								1						2
R241	9/28/89 - 9:00am	1			1								1					1	4
R243	9/11/89 - all day						1					1							2
R244	9/15/89 - 8:30am				1		1			1	1	1						1	6
R245	10/27/89 - 8:15am			1	1					1	1							1	5
R245	10/5/89 - 9:45am					1	1					1						1	4
R245	9/11/89 - all day						1	1	1	1		1							5
R245	9/14/89 - 12:30pm	1					1		1			1							4
R245	9/21/89 - 1:30am	1			1	1				1		1						1	6
R245	9/22/89 - 9:10am			1			1	1	1	1		1							7
R245	9/22/89 - 9:15am				1					1		1							3
R245	9/25/89 -												1						1
R245	9/29/89 - 9:15am				1	1	1						1					1	5

TABLE D-1 COMPLAINT FORM RESPONSES

Loc Room	Date of Complaint	Eye Irrit.	Contact Lenses	Nose Irrit.	Throat Irrit.	Nature of Complaint			Respiratory Response	Space is Stuffy	Space has Odor	Space Too Warm	Space Too Cold	Lighting Inadequate	Light Flickers	Light qual. if a source of Irritation	Noise in space is Irritating	Other Complaints	Total
R245													1						1
R247												1						1	2
R250	10/10/89 - 9:20am												1					1	2
R250	10/11/89 - 9:20am												1					1	2
R250	10/12/89 - 9:20am												1					1	2
R250	10/13/89 - 9:20am												1					1	2
R250	10/16/89 - all day	1							1									1	3
R250	10/17/89 - all day	1							1									1	3
R250	10/20/89 - all day	1							1									1	3
R250	10/23/89 - am	1								1		1						1	4
R250	10/24/89 - 9:40am	1																1	2
R250	10/25/89 - am	1																1	2
R250	10/26/89 - 9:30am	1																1	2
R250	10/27/89 - 9:30am	1																1	2
R250	10/30/89 - 9:25am	1																1	2
R250	10/31/89 - 9:25am	1																1	2
R250	10/5/89 - all day									1		1						1	3
R250	11/1/89 - 9:25am	1																1	2
R250	11/10/89 - am	1																1	2
R250	11/10/89 - am											1						1	2
R250	11/14/89 - morning	1																1	2
R250	11/15/89 - 9:25am	1										1						1	3
R250	11/15/89 - am											1						1	2
R250	11/16/89 - 9:25am	1																1	2
R250	11/17/89 - 9:25am	1										1						1	3
R250	11/2/89 - 9:25am	1																1	2
R250	11/2/89 - am																	1	1
R250	11/3/89 - 9:25am	1										1						1	3
R250	11/6/89 - am	1										1						1	3
R250	11/7/89 - am	1																1	2
R250	11/8/89 - am	1																1	2
R250	11/8/89 - am											1						1	2
R250	11/9/89 - am	1																1	2
R250	9/19/89 - 8:00am																	1	1
R250	9/27/89 - 8:30am											1						1	2
R250	9/29/89 - all day											1						1	2
R253	9/15/89 - 8:00am												1					1	2
R254	9/22/89 - 9:00am	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
R256	10/5/89 - am hours									1		1			1			1	4
R260	10/11/89 - 2:25pm						1			1		1						1	4
R260	10/5/89 - all day									1		1						1	2
R261												1						1	2
R302	10/16/89 - am hours											1	1					1	3
R302	10/3/89 - 9:00am										1	1						1	3
R302	9/24/89-9/25/89												1					1	1
R304	9/15/89 -													1				1	2
R307	10/10/89 - 11:30am												1		1			1	3
R307	10/10/89 - 11:45am												1					1	1
R307	10/19/89 -12:45 pm					1	1		1		1		1					1	6
R309	10/4/89 - 2:00pm					1				1								1	3
R309	9/15/89 - am hours								1	1								1	3
R310	10/10/89 - am hours												1					1	1
R310	10/16/89 - am hours										1		1					1	2
R310	10/18/89 - Am hours			1	1	1					1							1	4
R310	11/8/89 - 8:30am												1					1	2
R310	9/26/89 - 10:00am												1					1	1
R312	10/18/89 - 8:00am				1		1	1			1							1	4
R314	10/2/89 - 8:30am																	1	1
R314										1	1	1						1	4
R316	9/18/89 - 11:25am	1		1	1	1	1		1	1		1						1	9



Loc	Date	Eye	Contact	Nose	Throat	Nature of Complaint			Respiratory	Space is	Space has	Space	Space	Lighting	Light	Light qual. i	Noise in	Other	Total
Room	of Compliant	Irrt.	Lenses	Irrt.	Irrt.	Dizziness	Headache	Nausea	Response	Stuffy	Odor	Too Warm	Too Cold	Inadequate	Flickers	A source of	space is	Complaints	
R318	9/22/89 0:00					1	1					1				Irritation	Irritating	1	4
R318	9/14/89 - 1:00pm						1					1						1	3
R318	9/15/89 - 12:17pm				1							1							2
R321	10/19/89 -												1						1
R321	9/14/89 - 10:00am						1			1				1					2
R334	10/10/89 - 1:40pm	1				1	1			1						1		1	7
R334	10/5/89 - 2:30pm				1	1	1	1		1		1				1			8
R337	10/3/89 - 9:00am									1						1		1	2
R337	9/14/89 -										1							1	2
R338	11/6/89 - 9:45am																	1	1
R339	10/11/89 - 2:30pm									1		1						1	3
R339	10/17/89 - 10:12am											1						1	3
R339	10/17/89 - 8:35am									1		1						1	3
R339	10/3/89 - 7:20am									1		1						1	3
R339	10/6/89 - 2:15pm									1		1						1	3
R339	9/14/89 - 1:00pm							2										1	3
R340	10/5/89 - 2:30pm				1	1	1											1	1
R340	11/6/89 - 10:15am																	1	4
R341	10/11/89 - 9:40am				1					1		1						1	1
R341	10/4/89 - 10:20am				1		1			1		1						1	4
R341	10/6/89 - 10:19am	1								1		1						1	4
R341	10/6/89 - 8:48 am									1		1						1	3
R343	10/16/89 - 7:30am																	1	1
R343	9/21/89 - 7:30am									1								1	2
R344&R342	9/28/89 -	1		1	1		1			1		1						1	7
R400	9/19/89 -												1					1	2
R402	10/3/89 - all day					1												1	3
R402	9/15/89 -																1	1	1
R406	9/14/89 - 11:30am	1								1									4
R410	11/16/89 - 10:00am																1	1	1
R411	11/7/89 - 11:00am							1			1							1	1
R411	9/22/89 - 9:30am	1		1		1	1			1	1	1			1		1	1	4
R411	9/22/89 - 9:30am	1		1		1	1			1	1	1			1			1	9
R411	9/22/89 - 9:30am	1		1		1	1			1	1	1			1				8
R414	10/19/89 - 1:30pm												1					1	8
R414	9/14/89 - 11:00am	1		1		1				1		1						1	2
R417	10/20/89 -											1					1	1	7
R417	9/14/89 -				1							1			1			1	3
R424	9/14/89 - 12:50pm								1	1	1	1					1	1	2
R431	10/10/89 - 10:15am						1		1							1		1	6
R431	9/18/89 -	1		1					1									3	3
R431	9/21/89 -								1									1	2
R503	9/15/89 -																		2
R508	10/3/89 - 10:10am									1		1					1	1	2
R508	9/19/89 - all day	1		1	1								1					1	2
R508	9/27/89 - 9:15am							1			1							1	5
R511	10/3/89 - 10:10am									1		1						1	3
R512/R503				1								1							2
S205	10/17/89 - am hours																	1	2
Safety Spec.		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	2
SOC	10/23/89 - 1:15pm												1					1	16
wst. rm	11/16/89 - 10:00am									1		1						1	2
	10/16/89 - 9:00am									1		1					1	3	
	9/14/89 - 10:20am	1		1	1	1	1	1		1		1							2
	9/14/89 - 10:20am	1		1	1	1	1	1		1		1							8
	9/14/89 - 10:20am	1		1	1	1	1	1		1		1							8
	9/14/89 - 3:40pm	1					1			1	1	1							8
	9/14/89 - all day	1		1	1	1	1	1	1	1		1						1	6
	9/14/89 - all day					1	1	1		1		1						1	10
	9/22/89 - am hours		1		1					1		1						1	5
																	1		4

TABLE D-1 COMPLAINT FORM RESPONSES

Loc	Date	Eye	Contact	Nose	Throat	Nature of Complaint			Respiratory	Space is	Space has	Space	Space	Lighting	Light	Light qual. is	Noise in	Other	Total
Room	of Complainant	Irrit.	Lenses	Irrit.	Irrit.	Dizziness	Headache	Nausea	Response	Stuffy	Odor	Too Warm	Too Cold	Inadequate	Flickers	a source of	space is	Complaints	
																irritation	irritating		
Totals		67	12	45	51	50	60	21	46	100	42	106	50	13	14	12	14	168	871

APPENDIX E-1

ANALYSIS METHOD FOR SPECIATION OF VOLATILE ORGANIC COMPOUNDS

The samples were analyzed by combined gas chromatography/mass spectrometry (GS/MS) for thirty-one target volatile organic compounds. The analyses were performed according to the methodology outlined in EPA Method TO-1 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, NC, April, 1984.

The analyses were performed using thermal desorption gas chromatography/mass spectrometry. The analytical system used for the analysis of the adsorbent traps was comprised of a Finnigan Model 4500 GC/MS/DS interfaced to a Tekmar 5010GT Automatic Desorber. A thick film (5 micron) cross-bonded 100% Dimethylpolysiloxane megabore column (RT_X -1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

A calibration standard analysis was performed prior to the analysis of the field samples. The calibration was performed by spiking pre-conditioned blank Tenax traps with a gas phase standard containing twenty-five (25) target organic compounds. The gaseous standards were introduced into the sample stream via a gas tight syringe and purged onto the adsorbent traps at ambient temperature. The traps were thermally desorbed in a counter current direction onto an open tubular cryogenic trap held at -150 degrees C. with liquid nitrogen. Five additional compounds (Ethanol, Acetone, Isopropyl alcohol, 2-Butanone, and 1,4-Dioxane) which were found in the samples were added to the target compound standard to get relative retention time and relative response data for these compounds.

The samples were collected on 60/80 Tenax TA adsorbent media traps which were prepared by Performance Analytical Inc. and submitted to Environmental Health and Engineering Inc. by Performance Analytical, Inc. prior to the sampling event. A contamination check was performed on the conditioned Tenax traps prior to submission to the field. Two field/trip plans were sent to the laboratory along with the field sample sets in order to assess contamination introduced to the traps during holding or transportation. No detectable levels of target analytes or tentatively identified compounds were found in the field/trip blanks.

All standards, field samples, and blanks were spiked with 500 nanograms each of 3 internal standard compounds and 3 surrogate compounds. Surrogate spike percent recoveries were well within acceptance criteria.

Tentatively identified compounds, those compounds not on the target list, except for the additional compounds mentioned above, were quantitated by peak area or height assuming a 1:1 response factor with the nearest internal standard. The additional five compounds mentioned above were quantitated using the response factors derived from the standard run on the second day of the analyses.

The results of the EPA TO-1 analyses are presented in Tables 7-1a through 7-1k.

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