ANALYSIS OF DIAGNOSED VS. EXPECTED CANCER CASES IN THE VICINITY OF THE REDFIELD PLUME AREA IN SOUTHEAST DENVER COUNTY, 1979-1999

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Introduction

The Redfield Site is approximately an eleven-acre area, which includes one building, in Southeast Denver County. The building has been used for various manufacturing processes since it was built in 1957. Rifle scopes and binoculars were manufactured at the facility from 1967 through 1998. The Brown Group, Inc. operated the business from 1979 through 1984. In 1984 the business was sold to the Redfield Rifle Scopes, Inc. Redfield operated the manufacturing facility until operations were terminated in 1998. Brown Retail currently owns the property and the building. In 1994, an environmental investigation identified the presence of chemicals in the groundwater under the site. The Colorado Department of Public Health and Environment (CDPHE) was notified of the contamination on July 1, 1994. The CDPHE took immediate action by requiring that Redfield Rifle Scopes, Inc. install permanent and temporary wells on the property to monitor the groundwater. Continued monitoring of the site indicated that the groundwater contamination concentrations were decreasing, and the company believed that the contamination was confined within the boundaries of the Redfield property.

In January of 1998, samples taken from the groundwater monitoring wells near the northeast corner of the Redfield property indicated that groundwater contamination might be moving off the Redfield site and into the surrounding neighborhood. In February 1998 an investigation into off-site contamination began, continues to this date and includes groundwater monitoring wells and indoor air testing in homes near the Redfield property, as well as groundwater treatment at the property boundary.

The CDPHE Environmental Toxicology Section approached the Agency for Toxic Substances and Disease Registry (ATSDR) in September 2001 requesting funds to conduct a public health consultation in the Redfield site area. The ATSDR defines a health consultation as a weight-of-evidence evaluation that: (1) identifies completed exposure pathways from a source contaminant to a human exposure (2) reaches conclusions on health impacts in the area of concern and (3) designs a mechanism for identifying further public health actions. This request was made in response to the community's health concerns about the possible increased risks of cancer due to exposures to the chemicals found in the groundwater contamination. The following chemicals have been detected in the indoor air: Dichloroethene (1,1-DCE), 1,1,1-Trichloroethene, 1,1,1-Trichloroethane, Perchloroethylene, Methylene Chloride, and Benzene. The most significant of these chemicals is 1,1- Dichloroethene (1,1-DCE). This chemical is also called 1,1-Dichloroethylene.

Methods

All cancers, except non-melanoma skin cancers and in situ cervical cancers that are diagnosed in Colorado, are reported to the Colorado Central Cancer Registry (CCCR) at the Colorado Department of Public Health and Environment. This invaluable data allows the CCCR to

effectively answer questions about cancer incidence in communities statewide. In this particular case, the CCCR was used to assess the incidence of cancer in the vicinity of the Redfield Rifle Scopes factory in southeast Denver County.

The study design used was an analysis of the number of cancers diagnosed in the Redfield area compared to a "typical," or expected, number of cancer cases, using data routinely collected by the cancer registry. The CCCR has maintained an incidence-based registry of all cancer cases reported at medical facilities in the Denver Metro area since 1979. Data from incidence-based registries provide several benefits compared to mortality-based data. Because incidence-based registries identify each case at the time a diagnosis of cancer is reported, rather than at the time of death, a more complete count of all cancers that have occurred, regardless of survival, is available. Incidence data will not be affected by differences in survival across cancer types and sites, whereas mortality data are susceptible to bias from differences in treatment and access to health care, particularly when more readily treatable types of cancer such as breast, prostate or thyroid cancer are being compared. In addition, medical records used to compile incidence-based registry statistics typically have more detailed information on cancer diagnoses (e.g., pathology reports, etc.) than is collected on death certificates, which are used to compile mortality statistics.

The epidemiological study design used in the analysis of diagnosed and expected numbers of cancer cases is descriptive and ecological. This type of study utilizing incident cancer registry data is frequently conducted in communities adjacent to potential environmental exposures, since they are efficient and can be completed within a reasonable period of time. This approach is usually viewed as exploratory and may generate hypotheses to be considered in additional studies, if appropriate. A weakness inherent in such studies is that information on potential causes of disease, other than the one under investigation (for example, lifestyle behaviors, occupation, or genetic predisposition) is lacking or limited.

Another weakness is that, because potential exposure is not actually measured over time for each individual a geographical area is used as a surrogate measure of exposure. The use of geographical residence raises the likelihood of exposure misclassification because exposure within the area is hypothesized to have occurred and to have been similar among individual inhabitants. Exposure misclassification may reduce the ability of the study to observe a statistically significant difference between groups. Lastly, the design of this cancer incidence analysis does not allow conclusions to be made about causal association between exposure and any single cancer or group of cancers. The study design and results only aid in assessing whether the total number of cancers or certain types of cancer are greater or less than expected, whether that difference is statistically significant, and whether future studies would be useful.

Choice of Study Area and Population Estimates

As part of this present investigation, cancer diagnosis counts were compared to expected counts for an area in the vicinity of the Redfield Rifles factory covering the time period of 1979-99, when cancer reporting was complete and the 1980, 1990, and 2000 Census years of population could be used. The boundaries of this area were selected for this analysis based on U.S. Census

designations combining census tract, census block group, and census block information. The study area had a population of 6,156 in 1980, 5,994 in 1990, and 7,512 in 2000. The study area was defined by census geography wherever possible. It includes census tract 49.50 (block group 1 from the 1980 census excluding cases north of Cherry Creek and block groups 3, 4, 5, and 6 from the 1990 census); census tract 49.00 (block group 2 plus selected addresses from block group 1 from the 1980 census and block group 3 from the 1990 census); census tract 51.02 (block group 1); census tract 49.88 (block group 3); census tract 49.97 (block group 4); census tract 51.03; census tract 52.00 (block groups 1, 3, and 4); and census tract 70.54 (two selected blocks from block group 7 from the 1980 census and block group 1 from the 1990 census). The boundaries of the study area starting at Colorado Blvd. and Cherry Creek and going clockwise are: Cherry Creek, S. Cherry St., E. Kentucky Ave., Cherry Creek Dr. S., E. Mississippi Ave., Cherry Creek, S. Monaco Pkwy., E. Jewell Ave., S. Oneida St., E. Evans Ave., S. Holly St., E. Louisiana Ave., S. Dahlia St., E. Mississippi Ave., S. Birch St., E. Arizona Ave., and S. Colorado Blvd. The study area includes only residential areas within these boundaries and thus, for example, excludes the commercial areas on the east side of Colorado Blvd. near Mississippi Ave.

See Map: Fig. 1

In order to conduct an analysis of this type, all the cancer cases diagnosed between 1979 and 1999 in this area were identified and registered with the CCCR according to standard procedures followed for all Colorado cancer cases. This identification process involved searching hospital medical charts, pathology laboratory records and examining death certificate information. The address at the time of diagnosis for each case was used to assign residence within the census boundaries. U.S. Census counts of population by age, race, and sex for 1980, 1990, and 2000 were obtained from the Colorado Division of Local Government (State Demographers Office) or from the U.S. Census Bureau website, www.census.gov.

Calculation of Diagnosed to Expected Ratios

Cancer rates from the 6-county Denver Metro Area (Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson), **excluding the study area,** were used as standards for calculating expected numbers of cancers for the study area because complete age-specific rates by race and sex were available from the CCCR. The Denver Metro area provides a large population base to generate reliable cancer rates. Each diagnosed case is coded to a census tract based on the address of the patient at the time the cancer was diagnosed. Cancer rates from the CCCR for men and women of comparable race groups and ages were used to calculate the expected number of cancers for the study area. A cancer rate is the number of new cancer cases diagnosed per 100,000 population. To calculate the expected number of cancers, the population in each census tract area by age, sex, and race was multiplied by the cancer rate for each age, sex, and race group in the Denver Metro comparison population. This method assures that any differences found are not due to differences in demographic composition. For example, census tracts with a higher proportion of elderly individuals would be expected to have higher cancer rates since incidence of most cancers increases dramatically with increasing age.

A diagnosed-to-expected ratio was then calculated by dividing the number of cancers diagnosed

in the study area by the number of expected cases. This ratio is called a standardized incidence ratio (SIR). If the SIR was greater than 1, then more cancer cases than expected were counted in the area. When this occurs, the next step would be to look more closely at that relationship. It is important to know if that ratio could have been higher by chance alone, so a confidence interval is calculated for the ratio. The confidence interval has a lower number (minimum value) and a higher number (maximum value). It is common to use a 95 percent confidence interval, which means that we are 95 percent sure that the true ratio is within the range between the lower and higher values. If the ratio is greater than 1, but the confidence interval includes the number 1, then the ratio is within expected statistical limits. If the confidence interval does not include the number 1, then the ratio is statistically significant at the $p < .05$ level, or there is less than a 5 per cent chance that the higher rate observed is due to chance alone. A statistically significant elevated ratio means that there were more diagnosed cases than expected and the result probably did not happen by chance.

Because the estimate of expected cancers is based on the larger Denver Metro region population, this estimate will be a central tendency, or average number, of expected cases for the time period 1979-1999. Cancer rates for specific populations, such as in smaller cities, towns, or neighborhoods, will likely be either higher or lower than the "average expected." Smaller populations tend to show greater variability. The variability of small populations is statistically reflected in the 95 percent confidence interval for the ratio of diagnosed to expected cases. Confidence intervals for small populations are wider than for large populations. When the expected number of cancer cases is small, slight increases can result in seemingly large diagnosed to expected ratios. For example, if only one case of cancer is expected in a small population in a given year, and two were actually diagnosed, the ratio would of course show a doubling of cases. But, in this situation, twice the number of expected cases would be within expected statistical limits. Statistical testing was not done on ratios with less than three diagnosed cases because of the inherent variability in such small numbers.

Tables 1, 2 and 3 display the number of diagnosed cancers in the study area during 1979-99 compared to the number that would be expected based on the population of male and female residents in the areas by race and age. These tables display ratios for individual types of cancer if there were three or more cases diagnosed for either gender during the 1979-99 time period. Tables 4 and 5 display additional detail for liver cancer and female kidney cancer cases. Cancer rates from the Cancer Registry for men and women of comparable race groups and ages were used to calculate the expected number of cancers for the areas. The ratios of diagnosed to expected cases along with the 95 percent confidence intervals for these ratios provide information about the relative rate of cancer in these areas.

Summary of Findings

All Cancers Combined. Table 1 shows that the overall number of 452 cancers diagnosed among males and females combined in the Redfield study area during 1979-99 was very close to the 453 cancers expected (ratio of diagnosed to expected cancers of 1.00). Lung cancer for males and females combined was statistically lower than expected, 31 cases compared to about 49 cases

expected for an observed expected ratio of 0.64. None of the individual cancer site ratios for males or females was statistically higher than expected, except kidney cancer among females. There were eight female kidney cancer cases compared to about three expected for a ratio of 2.58 (see Table 5 for further detail). The ratio of diagnosed liver cancer cases to expected cases (ratio of 2.13, six cases compared to about three cases expected) was within expected statistical limits, but since liver cancer has potential relevance to solvent exposure, additional detail by race/ethnicity and age are presented in Table 4.

Table 1 – Number of Cancer Diagnoses Compared to the Expected Number in the Redfield Area, 1979-99 – Males and Females

	Cancers Diagnosed	Cancers Expected	Ratio of Diagnosed to Expected (SIR)	95% C.I. for Ratio
All Cancers Combined	452	452.918	1.00	(0.91-1.09)
Esophagus	5	3.119	1.60	(0.52-3.75)
Colorectal	48	47.201	1.02	(0.75-1.35)
Liver	6	2.818	2.13	(0.78-4.64)
Pancreas	9	8.720	1.03	(0.47-1.96)
Larynx	7	4.188	1.67	(0.67-3.45)
Lung	31	48.756	0.64*	(0.43-0.90)
Melanoma	21	21.238	0.99	(0.61-1.51)
Female Breast	73	77.541	0.94	(0.74-1.18)
Cervix	30	23.828	1.26	(0.85-1.80)
Uterus	13	11.716	1.11	(0.59-1.90)
Ovary	15	9.143	1.64	(0.92-2.71)
Prostate	62	59.405	1.04	(0.80-1.34)
Testis	4	4.854	0.82	(0.22-2.11)
Bladder	17	18.473	0.92	(0.53-1.47)
Kidney	10	8.626	1.16	(0.56-2.13)
Brain & CNS	8	7.537	1.06	(0.46-2.09)
Thyroid	5	7.751	0.65	(0.21-1.51)
Lymphoma	23	19.927	1.15	(0.73-1.73)
Myeloma	7	4.183	1.67	(0.67-3.45)
Leukemia	12	11.315	1.06	(0.55-1.85)

Note: Diagnosed/Expected ratios that have a 95% Confidence Interval that brackets the value 1.000 are not considered statistically high or low.

* Ratio is statistically significant at p=0.05 level.

NC = not calculated due to less than 3 diagnoses.

Male Cancers. Table 2 shows that the overall number of cancers diagnosed among males in the study area during 1979-99 was not statistically higher than the expected number calculated. There were 201 cancers diagnosed among males compared to about 219 cancers expected, for a standardized incidence ratio of 0.92.This table also displays ratios for individual types of cancer if there were three or more cases diagnosed for males (or for females). None of the individual cancer ratios evaluated for males was statistically elevated, and lung cancer among men was statistically lower than expected (19 cases compared to about 30 cases , for a ratio of 0.63).

Table 2 – Number of Cancer Diagnoses Compared to the Expected Number in the Redfield Area, 1979-99 - Males

	Cancers Diagnosed	Cancers Expected	Ratio of Diagnosed to Expected (SIR)	95% C.I. for Ratio
All Cancers Combined	201	219.204	0.92	(0.80-1.05)
Esophagus	2	2.352	0.85	NC
Colorectal	23	25.431	0.90	(0.57-1.36)
Liver	4	1.824	2.19	(0.60-5.61)
Pancreas	5	4.568	1.09	(0.35-2.56)
Larynx	5	3.294	1.52	(0.49-3.55)
Lung	19	30.279	0.63*	(0.38-0.98)
Melanoma	7	12.047	0.58	(0.23-1.20)
Prostate	62	59.405	1.04	(0.80-1.34)
Testis	4	4.854	0.82	(0.22-2.11)
Bladder	8	14.110	0.57	(0.24-1.12)
Kidney	2	5.521	0.36	NC
Brain & CNS	7	4.323	1.62	(0.65-3.34)
Thyroid	0	2.024	0.00	NC
Lymphoma	13	11.466	1.13	(0.60-1.94)
Myeloma	4	2.344	1.71	(0.46-4.36)
Leukemia	9	6.737	1.34	(0.61-2.54)

Note: Diagnosed/Expected ratios that have a 95% Confidence Interval that brackets the value 1.000 are not considered statistically high or low.

* Ratio is statistically significant at p=0.05 level.

NC = not calculated due to less than 3 diagnoses.

Female Cancers. Table 3 shows that the overall number of cancers diagnosed among females in the study area during 1979-99 was not statistically higher than expected. There were 251 cancers diagnosed among females compared to about 234 cancer expected, for a ratio of 1.07. Ratios for individual types of cancer are displayed if there were three or more cases diagnosed for females (or for males). None of the individual cancer site ratios for females was statistically higher than expected, except kidney cancer. There were eight female kidney cancer cases compared to about three expected, for a ratio of 2.58 (see Table 5 for further detail).

Table 3 – Number of Cancer Diagnoses Compared to the Expected Number in the Redfield Area, 1979-99 - Females

	Cancers Diagnosed	Cancers Expected	Ratio of Diagnosed to Expected (SIR)	95% C.I. for Ratio
All Cancers Combined	251	233.714	1.07	(0.95-1.22)
Esophagus	3	0.767	3.91	(0.81-11.44)
Colorectal	25	21.770	1.15	(0.74-1.69)
Liver	2	0.994	2.01	NC
Pancreas	4	4.152	0.96	(0.26-2.46)
Larynx	2	0.894	2.24	NC
Lung	12	18.477	0.65	(0.34-1.13)
Melanoma	14	9.191	1.52	(0.83-2.56)
Breast	73	77.541	0.94	(0.74-1.18)
Cervix	30	23.828	1.26	(0.85-1.80)
Uterus	13	11.716	1.11	(0.59-1.90)
Ovary	15	9.143	1.64	(0.92-2.71)
Bladder	9	4.363	2.06	(0.95-3.91)
Kidney	8	3.105	2.58*	(1.11-5.07)
Brain & CNS	1	3.214	0.31	NC
Thyroid	5	5.727	0.87	(0.28-2.04)
Lymphoma	10	8.461	1.18	(0.57-2.17)
Myeloma	3	1.839	1.63	(0.34-4.77)
Leukemia	3	4.578	0.66	(0.14-1.92)

Note: Diagnosed/Expected ratios that have a 95% Confidence Interval that brackets the value 1.000 are not considered statistically high or low.

* Ratio is statistically significant at p= 0.05 level.

- NC = not calculated due to less than 3 diagnoses.

Liver Cancers. Table 4 examines the number of liver cancers diagnosed by race/ethnicity and age. There were too few Hispanic and Black cases to evaluate statistically, and the number of cases among white, non-Hispanics (5 compared to about 2 cases expected, for a ratio of 2.36) was within expected statistical limits. The number of cases aged 55-64 was elevated, with the ratio of 4.87, (three cases compared to about one case expected) being statistically high.

Additional assessments of all male and female liver cancer cases included: (1) a variety of occupations with no particular pattern, (2) **of the three cases that had recorded information about smoking status on Cancer Registry abstracts, two (or 67%) were listed as smokers, (3) one case was listed as having a history of alcohol abuse,** and (4) the distribution of histologic cell types among the six cases was similar to Denver Metro liver cancer cases with hepatocellular carcinomas, accounting for 50% of cases in the Redfield area and about 61% of cases in the Denver area. Cholangiocarcinomas accounted for 17% of cases, compared to 18% in the Denver area. All other types accounted for 33% of, compared to 21% in the Denver area.

Geographic Distribution of Cancer Cases

The geographic distribution of the diagnosed liver cancer cases in the 55-64 year olds did not indicate an association of those cases with any more exposed areas of the Redfield Plume. Investigation of the three cases, using the Redfield Site Status of Pre-Mitigation Indoor Air Test Map 2002 (Fig. 2), comparing the home addresses of the cases with the site map resulted in the following findings:

1. One case did not live in the plume area.
2. One case had a concentration level of 1,1-DCE indoor air of less than 0.49 micrograms per cubic meter of air, less than the action level.
3. One case had a concentration level of 1,1-DCE indoor air of greater than 0.49 micrograms per cubic meter, but less than 4.9 micrograms per cubic meter of air.

Table 4– Number of Liver Cancer Diagnoses by Race and by Age Compared to the Expected Number in the Redfield Area, 1979-99

Race	Cancers Diagnosed	Cancers Expected	Ratio of Diagnosed to Expected (SIR)	95% C.I. for Ratio
White Non-Hispanic	5	2.120	2.36	(0.76-5.51)
Hispanic	0	0.183	0.00	NC
Black	0	0.173	0.00	NC
Age				
25-34	1	0.121	8.26	NC
35-44	0	0.211	0.00	NC
45-54	0	0.397	0.00	NC
55-64	3	0.616	4.87*	(1.004-14.24)
65-74	2	0.884	2.26	NC
75+	0	0.498	0.00	NC
Total	6	2.818	2.13	(0.78-4.64)

Note: Diagnosed/Expected ratios that have a 95% Confidence Interval that brackets the value 1.000 are not considered statistically high or low.

* Ratio is statistically significant at p=0.05 level.

NC = not calculated due to less than 3 diagnoses.

Etiologic Features of Liver Cancer (Hepatocellular Cancer)

Primary liver cancer is the fifth most common cancer worldwide, accounting for 5.4 % of new cancer cases each year. In the United States, an estimated 7,000 new cases of primary liver cancer occur annually. (Greenlee, 2000). Epidemiologic studies have established a close association between chronic Hepatitis B Virus (HBV) infection and liver cancer. Also, regular consumption of alcohol (closely controlled for tobacco use) has been confirmed widely to increase cancer frequency at various sites; liver in particular. (Thun,1997; Talamini, 1998).

Female Kidney Cancers. Table 5 examines the number of female kidney cancers by race/ethnicity and age. There were no Hispanic or Black cases, but the ratio of 2.54 (7 diagnosed cases compared to about 3 expected cases) among white, non-Hispanic females was statistically high. All of the individual age groups that had any cases reported had elevated ratios, though all were also within expected statistical limits.

Additional assessments of female kidney cancer cases showed: (1) a wide variety of occupations with no particular pattern, (2) **of the 7 cases that had recorded information about smoking status on Cancer Registry abstracts, five (or 71%) were listed as smokers**, and (3) the distribution of histologic cell types among the 8 cases was comparable to Denver Metro female kidney cancer cases with adenocarcinomas (renal cell carcinomas and other adenocarcinomas) accounting for all of the cases in the Redfield area and 74% of cases in the Denver area.

Geographic Distribution of Cancer Cases

The geographic distribution of the diagnosed female kidney cancer cases did not indicate an association of those cases with any more exposed areas of the Redfield Plume. Investigation of the eight cases, using the Redfield Site Status of Pre-Mitigation Indoor Air Test Map 2002, comparing the home addresses of the cases with the site map resulted in the following findings:

1. Three cases did not live in the plume area.
2. One case had a concentration level of 1,1-DCE of 1.5 micrograms per cubic meter of indoor air.
3. Two cases had a concentration level of 1,1-DCE of less than 0.49 micrograms per cubic meter of indoor air, less than the action level.
4. Two cases, located in the Colorado Department of Transportation (CDOT) plume area, had a concentration level of 1,1-DCE of less than 0.49 micrograms per cubic meter of indoor air, less than the action level.

Table 5 – Number of Kidney Cancer Diagnoses by Race and by Age Compared to the Expected Number in the Redfield Area, 1979-99 - Females				
Race	Cancers Diagnosed	Cancers Expected	Ratio of Diagnosed to Expected (SIR)	95% C.I. for Ratio
White Non-Hispanic	7	2.759	2.54*	(1.02-5.23)
Hispanic	0	0.158	0.00	NC
Black	0	0.143	0.00	NC
Age				
25-34	1	0.102	9.80	NC
35-44	0	0.239	0.00	NC
45-54	0	0.501	0.00	NC
55-64	3	0.733	4.09	(0.84-11.97)
65-74	2	0.839	2.38	NC
75+	2	0.571	3.50	NC
Total	8	3.105	2.58*	(1.11-5.07)

Note: Diagnosed/Expected ratios that have a 95% Confidence Interval that brackets the value 1.000 are not considered statistically high or low.

*Ratio is statistically high at p=0.05 level.

NC = not calculated due to less than 3 diagnoses.

Etiologic Features of Kidney Cancer (Renal Carcinoma)

Current epidemiological literature indicates that the incidence of renal cell carcinoma represents approximately 2-3% of new cancers per year. Men are affected twice as often as women, and the average age at diagnosis is sixty years (Greenlee, 2000). Risk factors that have been proved or implicated in the causes of renal cancer include smoking, obesity, analgesic abuse, and certain occupational exposures to agents such as cadmium. Approximately one per cent of renal cancers cluster in families. Also, there are studies that show that individuals, who smoke, whether they are men or women, have an increased risk of renal carcinoma. (La Vecchia, 1990; Talamini, 1990; Yuan, 1998).

Discussion and Conclusions

Agent of Concern

1,1-DCE is the primary chemical of concern based on the concentrations measured in homes. However, no human health effects have yet been observed at the concentration levels measured in indoor air in homes near the Redfield site. According to the National Institute for Occupational Safety and Health (NIOSH), health effects can be detected in humans who have been exposed to levels at or above 99,000 micrograms per cubic meter of air. The lowest effects from chronic exposure to 1,1-DCE seen in animal studies (rats) were seen at 15,000 micrograms per cubic meter of air (ATSDR 1999). These amounts are 755 and 115 times, respectively, greater than one of the highest levels found in the neighborhoods to date. The CDPHE action level of 0.49 micrograms per cubic meter of air is a health protective level, which will keep the indoor levels of 1,1-DCE so low that the risk of cancer attributed to a 30-year exposure to 1,1-DCE will be less than 1 in 100,000 people.

Statistical Analysis

In any study examining many cancers in a variety of population groups, there is the possibility of finding statistical elevations, which may be due to chance. This statistical issue is commonly referred to as the "multiple comparisons" problem and comes about because with multiple statistical tests being conducted using a 95% confidence interval, about 5% of tests would be predicted to be statistically significant by chance alone, about 2.5% higher than expected and 2.5% lower. In this study, with about 50 independent statistical tests conducted on separate cancer sites by gender, there was one ratio statistically higher than expected (2% of the tests, compared to about 2.5% predicted by chance alone) and one ratio lower than expected (2% of the tests compared to about 2.5% predicted by chance alone). Evaluating all 87 comparisons done, including all cancers combined, both genders combined for all cancers and individual cancers, and additional tests done by race and age for two cancers (liver and female kidney), four ratios were statistically higher than expected (4.6% of the tests) and two ratios were statistically lower than expected (2.3% of the tests). Since these evaluations are close to what would be expected by chance, the results of this study should be interpreted with caution.

Cancer Distribution

Of the eight cases of female kidney cancer, all of the resident locations were dispersed within the study area. Seven of the eight homes associated with female kidney cancer had **no exposure** or **less than the action level of exposure** (0.49 micrograms per cubic meter of air) to the agent of concern, 1,1-DCE. Also, there were no specific age groups that experienced a higher incidence of renal carcinoma and five of the seven diagnosed cases were reported to be smokers; a risk factor associated with renal carcinoma.

Of the three cases of liver cancer, in the 55-64 year age group that were statistically elevated, all of the resident locations were dispersed within the study area. Two of the three homes had **no exposure** or **less than the action level of exposure** (0.49 micrograms per cubic meter of indoor air) to the agent of concern, 1,1-DCE. Also, one of the three cases was reported to be a smoker

and alcohol abuser; both known to be risk factors associated with liver cancer.

Based on the above information, there is no indication of an elevated incidence of cancer attributable to 1,1-DCE or any other chemical constituents of the Redfield plume. If there is further evidence that the concentrations of 1,1-DCE increase to a level where there may be human health concerns, or that prior exposures differ significantly from those documented, a health consultation will be performed.

Recommendations

- Continued groundwater monitoring in the Redfield site by the Brown Retail Group, Inc.
- Continued regulatory oversight conducted by the CDPHE Hazardous Materials Waste Management Division.

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