# CANCER INCIDENCE NEAR THE SANTA SUSANA FIELD LABORATORY

# 1978-1989

California Department of Health Services

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# EXECUTIVE SUMMARY

In 1948, Rocketdyne began operating the Santa Susana Field Laboratory (SSFL), located at the southeastern border of Ventura County. Since that time the SSFL has been engaged in a variety of federally-supported research and development activities including the operation of nuclear reactors, the handling of plutonium, rocket engine testing and other activities involving radioactive and other toxic materials. The United States Department of Energy (DOE) and its predecessor agencies have been a primary source of support for these activities. The use of toxic and radioactive substances at the SSFL has been of concern to some area residents and organizations for many years.

In January, 1991, the California Department of Health Services (DHS) issued a preliminary statistical report suggesting that a higher than usual number of bladder cancer cases were diagnosed in one time period (1983-1987) among residents of some areas on the Los Angeles County side of the SSFL. This report included recommendations for further analysis. Public comment on the report included additional recommendations. These were:

1. Limit analyses to invasive cancers among non-Hispanic Whites to reflect the population near the SSFL, and determine whether the results are similar for males and females;

2. Include data from Ventura County;

3. Add more recent years of data, if available;

4. Include additional types of cancer that might be associated with radiation exposure.

## *Methods of Analysis*

This report uses two methods of analysis in order to take advantage of the more detailed and historical data available for Los Angeles County than are available for Ventura County.

For Los Angeles County, data available from 1978-88 were used in conjunction with special population estimates for the area near the SSFL to compare cancer rates among non-Hispanic Whites living near the SSFL to those rates for the county as a whole. These rate ratios ("Standardized Incidence Ratios") are presented for the same geographic area near the SSFL as in the 1991 preliminary report, and include one additional year of data (1988).

In Ventura county, cancer data are currently available only for 1988 and 1989. There are no special estimates of the population in Ventura near the SSFL that could be used to calculate cancer rates for these years. Instead, this report presents information on the proportion of cancer types diagnosed during 1988-89 among Ventura County residents living near the SSFL, compared to the proportion of those cancers among all other Ventura County residents ("Proportional Incidence

Ratios"). For 1988-89, a similar analysis was conducted for Los Angeles County and both counties combined.

## *Results*

Very radiosensitive cancers were not more common among residents near the SSFL in any of the time periods examined or geographical comparisons made. Somewhat higher, and somewhat lower, incidence of some cancer types was seen among residents near the SSFL, but there was no consistent pattern between residents of the two counties, or between men and women. The rate of bladder cancer was higher in 1983-88 among men, but not women, who lived in Los Angeles County near the SSFL than in the County as a whole. It was not higher in the earlier time period (1978-82). Comparing the two counties during 1988-89, the proportional incidence of bladder cancer was somewhat higher among Los Angeles County residents living near SSFL, but somewhat *lower* among nearby Ventura County residents.

Men living near the SSFL in Ventura County had a higher proportion of lung cancers than men living elsewhere in the County, but women did not, nor did either men or women near the site in Los Angeles County. Cases of all types of cancer for which radiation may be one cause were somewhat more common among men living near the SSFL in both counties, but were not more common among women living in either county.

All epidemiology studies have some limitations. For these analyses, there was not information on length of residence near the SSFL, nor on people who once lived nearby but were diagnosed with cancer after moving away. Environmental, occupational and lifestyle factors among the individuals with cancer were also unavailable. The relatively small number of cases of cancer in the five-mile radius during the years examined also limits the ability to find risks that may exist. These limitations should be kept in mind, but do not change the overall conclusions of the report.

## *Conclusions*

These follow-up analyses suggest that people living near the SSFL are not at increased risk for developing cancers associated with radiation exposure. The findings are consistent with the earlier DHS report that indicated an increase in the incidence of bladder cancer in people living in Los Angeles County near the SSFL, although this increase appears to be restricted to men in Los Angeles County only. There was also an increased proportion of lung cancer among Ventura men. Lack of an increase in the most strongly radiosensitive cancers suggests causes other than radiation. Because lung and bladder cancers tend to be cancers that are strongly associated with other risk factors (smoking and non-radiation occupational exposures), it is important to consider these alternative explanations when initiating the DOE-sponsored worker health study among Rocketdyne employees.

## ACKNOWLEDGMENTS

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# CANCER INCIDENCE NEAR THE SANTA SUSANA FIELD LABORATORY 1978-1989

## BACKGROUND

This report is a follow-up to a preliminary analysis of cancer incidence near Rocketdyne's Santa Susana Field Laboratory (SSFL) released by the Department of Health Services (DHS) in January of 1991. The Santa Susana Field Laboratory has been engaged in a variety of federally-supported research and development activities since 1948, including the operation of nuclear reactors, the handling of plutonium, rocket engine testing and other activities involving radioactive and other toxic materials. The January 1991 report examined cancer incidence rates among Los Angeles County residents living near the SSFL, compared to those for Los Angeles as a whole, for the time period 1978-1987. The preliminary results suggested that there might be an elevation of bladder cancer incidence among residents of some census tracts near the SSFL in Los Angeles County, compared those living elsewhere in Los Angeles. This work was done in response to community concerns regarding cancer risks which may have resulted from the presence of radioactive materials on the SSFL site.

The current analysis is designed to follow-up on the recommendations of the earlier report, and to extend analyses to include selected sites of cancer not included in the initial report. Specific objectives of these follow-up analyses are:

1. For Los Angeles County census tracts designated in the preliminary report, to recalculate the bladder cancer incidence ratios for *invasive* cancers *only* among non-Hispanic Whites by sex;

2. For the area near the SSFL in Ventura County, to evaluate relative incidence for bladder cancer, and other possibly radiogenic cancers;

3. To add additional cancer information reported since the preliminary analyses, as available;

4. To also analyze cancers not included in the preliminary report (such as breast cancer) for which there is some evidence of radiation-related risks.

## METHODS

### *Definition of study area and cancers of interest*

These analyses are designed to assess the relative frequency of different types of newly diagnosed cancers among people living in census tracts within a five-mile radius of the Santa Susana Field Laboratory (SSFL), a site owned and operated by Rocketdyne corporation. The SSFL is located in Ventura County on the Los Angeles County border. Hence, the population living in the census tract areas of interest includes residents of both Ventura and Los Angeles counties. Map 1 shows the SSFL and the area encompassed by a five-mile radius that was used to identify the census tracts of study for the preliminary DHS analysis, and for this follow-up.

Because initial public concerns were prompted by the presence of radioactive substances on the SSFL site, cancers were grouped based on the evidence for radiogenic causes, as summarized in BEIR V (Committee on the Biological Effects of Ionizing Radiation's report on Health Effects of Exposure to Low Levels of Ionizing Radiation)[1]. Cancers were grouped this way to maximize the likelihood for identifying excess risks for radiogenic cancers for the limited time period for which cancer incidence information was available. Sufficient numbers of cancers are required for statistical assessment to identify any excess risks of cancer. These analyses present information for the following groups of cancers.

1. ***Very Radiosensitive Cancers:*** These are cancers for which there is very strong scientific evidence for the causal influence of radiation. They include cancers of the thyroid and bone, and all of the leukemias except for chronic lymphocytic leukemia (which is not radiogenic).

2. ***Moderately Radiosensitive Cancers:*** These are cancers for which there is good evidence for radiation-related effects under certain circumstances. Since they also represent very different types of malignancies, and are among the most commonly occurring cancers, they are presented separately and include lung cancer and cancer of the female breast.

3. ***Possibly Radiosensitive Cancers:*** These are cancers for which there is much less evidence for radiogenic causes, but which were included in BEIR V with at least some suggestive evidence for such a relationship. They include cancers of the stomach, esophagus, liver, brain, bladder and other urinary organs, parathyroid, salivary gland, and multiple myeloma. Because it was the focus of concern from the earlier DHS analysis, and is also somewhat more common in occurrence than other cancers in this group, data are also presented separately for cancer of the urinary bladder.

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1 National Research Council, Commission on Life Sciences, Board on Radiation Effects Research, Committee on the Biological Effects of Ionizing Radiation. Health Effects of Exposure to Low Levels of Ionizing Radiation, BIER V. National Academy Press, Washington D.C., 1990.

## *Standardized incidence in Los Angeles County*

Los Angeles County has been covered by a population-based cancer reporting system since 1972. This registry is operated by the Cancer Surveillance Program (CSP) at the University of Southern California. The calculation of cancer incidence rates requires not only complete ascertainment of newly diagnosed cancers, but also demographic detail on the number of people residing in the area of interest. Special population estimates for the time period 1978-1988 were generated by USC for non-Spanish Surname Whites residing in the census tracts identified in the preliminary DHS report. These included census tract numbers 1132, 1343, 1344, 1351, and 1352 (see Map 1). CSP examined the difference in incidence rates for invasive cancers between non-Spanish Surname Whites residing near the SSFL (in the designated L.A. County census tracts) at diagnosis and rates for invasive cancers occurring among all non-Spanish Surname Whites residing in LA County.

For each of the cancer types identified above, rate ratios multiplied by 100 (Standardized Incidence Ratios[2], SIR) were computed separately for males and females, adjusting for age. As a measure of the stability of the SIR, 95% confidence intervals[3] are presented for each SIR. An SIR of 100 indicates that the rate among those living near the SSFL is identical to that among those living in LA County as a whole. A 95% confidence interval which includes 100 indicates that the estimated SIR is not significantly different than 100.

## *Proportional incidence in Ventura and Los Angeles Counties*

Ventura county has been part of the California statewide cancer surveillance reporting system (the California Tumor Registry, CTR) since 1988. Census tracts of interest in Ventura County near the SSFL represent an area of rapid population growth between 1980 and 1990. At the census tract level, Ventura has no special intercensal population estimates between 1980 and 1990 with detail on the distribution by age, race and sex. It is, therefore, not possible at this time to compute incidence rates separately for tracts near the SSFL and the remainder of Ventura County. It is, however, possible to examine whether or not the proportion of cases of a single cancer type in one area of the county differs from that for the remainder of the county. For this analysis, cancer incidence data were available for both Ventura and Los Angeles counties for 1988 and 1989[4]. A slightly different definition of "Latino" was used, based on whether the patient was identified as being of Hispanic descent or origin. These analyses, conducted by the CTR, were limited to non-Hispanic Whites, which comprise the vast majority of the population in the area of interest.

For proportionate incidence analysis, it was possible to obtain more detailed census tract information than was used in the preliminary report and the SIR analysis above. The area of

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2 Breslow NE, Day NE. Statistical Methods in Cancer Research. Volume II. IARC Scientific Publications No. 82. International Agency for Research on Cancer, Lyon, 1987, pp 61-79.

3 Mulder PGH. An exact method for calculating a confidence interval of a Poisson parameter. American Journal of Epidemiology 117(3):377, 1983.

4 July 1991 regional submission tapes to the CTR

interest for this analysis was defined as any tract at least partially within the five-mile radius of the SSFL (shown in Map 2). In Los Angeles county this included census tracts 1131, 1132.01, 1132.02, 1132.03, 1133.02, 1133.03, 1134.02, 1342.01, 1343.01, 1343.02, 1343.03, 1344.01, 1344.02, 1345, 1351.01, 1351.02, 1352.01, 1352.02, 1352.03, 1372.01, 1372.02, 1373.01, 1373.02, 1373.03, 8002, 8003.01, and 9203.03 (excluding cases with a city name of Agoura). In Ventura County this included census tracts 74.01, 75.02, 75.03, 79, 80.01, 80.02, 80.03, 81, 82, 83.01, 83.02, 84.01, 84.02 and 85. A small number of cases (21) lacking census tract designation, but with a city name within the five-mile radius were also included in the area of interest. These city names included Calabasas, Canoga Park, Chatsworth, Hidden Hills, Santa Susana, Susana Knolls, Simi Valley, West Hills and Woodland Hills.

Proportional incidence ratios were computed using an age-adjusted (Mantel-Haenszel) odds ratio[5] for each of the cancer groups listed above, by sex. The odds ratio represents the odds of having a particular cancer type among all cancer patients, given that a person lived in the area of interest (near the SSFL) at diagnosis compared to the odds of having that cancer type given that a person lived outside of the area of interest. This can also be thought of as the risk of having a particular kind of cancer among all people with cancer near the SSFL site compared to that among all people with cancer who did not live near the SSFL at diagnosis.

Odds ratios were computed for each of the selected cancer types for the designated area in Ventura County compared to the rest of Ventura County, for the designated area in Los Angeles County compared to the rest of Los Angeles County, and for the combined designated areas in both counties compared to the combined balance of both counties. An odds ratio of 1.0 indicates that the proportion of individuals with a certain cancer type living near the SSFL is the same as that among individuals living outside the area of interest. As a measure of the stability of the odds ratio, 95% confidence intervals were computed for each odds ratio. A 95% confidence interval which includes 1.0 indicates that the estimated odds ratio is not significantly different than 1.0.

## *Power to detect differences*

Because only limited years of data are available to evaluate cancer incidence for the small geographic area near SSFL compared to elsewhere in the two counties, it is possible that a study of this type could simply have insufficient information to detect true differences if they exist. For each cancer type, by geographic area and sex, estimates were made of the lowest standardized incidence ratio and proportional incidence ratio for which there was at least an 80% chance of detecting significantly (two-sided $p<0.05$) elevated incidence. These calculations for the SIRs

5 Breslow NE, Day NE. Statistical Methods in Cancer Research. Volume II. IARC Scientific Publications No. 82. International Agency for Research on Cancer, Lyon, 1987, pp 115-116.

were done using the method described by Armstrong[6], and for the PIRs using the method described by Oliphant and McHugh[7].

## RESULTS

### *Standardized incidence (Los Angeles)*

Table 1 summarizes the number of cases included in the analysis of Standardized Incidence Ratios for the area near the SSFL in Los Angeles County for a five year (1978-82) and six year (1983-1988) time period. Even for these rather broad time periods there is a small number of cases of very radiosensitive cancers by sex. Cancers of the female breast and of the lung, which are the most common of human cancers, contribute considerably larger numbers to the analysis, over 100 cases for all but one comparison. The mix of possibly radiosensitive cancers contributes relatively few cases by specific site, except for bladder which makes the largest single contribution to the site group. Restricting these analyses to only invasive cancers among non-Hispanic Whites reduced the observed number of bladder cancer cases by about 20%. These analyses include 59 cases of bladder cancer diagnosed among residents near the SSFL between 1978-82 compared to 73 in the preliminary report, and 79 cases in 1983-88 compared to 92 cases diagnosed 1983-87 in the preliminary report.

Table 2 summarizes the SIRs and their 95% confidence intervals for each cancer group by time period and by sex. Across comparisons only bladder cancer among men in the more recent time period shows a significantly elevated SIR (SIR=132.6, 95% CI= 100.5-171.9), as does the possibly radiosensitive site group for men in that time period (SIR=124.9, 95% CI=105.3-147.1) to which bladder contributes nearly half of the cases. A significantly *lower* SIR is evident for lung cancer among women living near SSFL during the earlier time period (SIR=74.8, 95% CI=55.7-98.4).

### *Proportional incidence (Ventura and Los Angeles)*

In all, there was a total of 43,269 cases of invasive cancer among non-Hispanic White residents of Ventura and Los Angeles Counties diagnosed in 1988 or 1989, and reported to the CTR as of July, 1991. Of these, 3,726 were among Ventura residents, and 39,543 among Los Angeles residents. Roughly 3% (1478) of all cases from these counties resided in the area of interest at diagnosis.

Table 3 summarizes the number of cases diagnosed among residents in the study area near the SSFL in Ventura and Los Angeles counties in 1988 and 1989. Because of the limited time period,

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6 Armstrong B. A simple estimator of minimum detectable relative risk, sample size, or power in cohort studies. American Journal of Epidemiology 126(2):356-358, 1987.

7 Oliphant TH and McHugh RB. Least significant relative risk determination in the case of unequal sample sizes. American Journal of Epidemiology 113(5):711-715, 1981.

and in spite of the broader geographic area covered in Los Angeles County, there are even fewer cases available for analysis than in the SIR analysis. For Ventura County, for example, in these two years there were only 12 new cases of bladder cancer diagnosed, and a mere 9 cases of very radiosensitive cancers.

Table 4 summarizes the proportional incidence ratios for each of the site groups of interest for Ventura and Los Angeles Counties combined. Only the proportion of possibly radiosensitive sites for men appears elevated (OR=1.25, 95% CI=1.01-1.55).

Table 5 summarizes the proportional incidence ratios for Ventura and Los Angeles Counties separately. Although the possibly radiosensitive site group does not evidence significantly elevated odds ratios by county, the estimates for each county are quite similar (1.23 and 1.26). In contrast to Los Angeles County, which has an odds ratio slightly below 1.0 for lung cancer in men, Ventura county men evidence a significantly elevated odds of being diagnosed with lung cancer (OR=1.66, 95% CI=1.17-2.37) during these two years.

### *Power to detect differences*

Table 6 summarizes the estimated lowest detectable standardized incidence ratio (by cancer type, sex, and time period) for which there is at least an 80% chance to detect a significant elevation (two-sided $p<0.05$). For both time periods, this study has the ability to identify reasonably small elevations in risk, all below two-fold elevations. For the more common cancers, such as lung and breast, these range from 20% to 40% excesses, while for more rare cancers the minimal detectable risks are higher.

Table 7 summarizes the estimated lowest detectable proportional incidence ratio (by cancer type, geographic area and sex) for which there is an 80% chance to detect a significant elevation ($p<0.05$). These data also suggest that these analyses have rather good power to detect fairly modest risk relationships, although not as much as for the standardized incidence ratios (which are based on larger numbers of cases). The study has optimal power to detect relatively small odds ratios for the two-county area combined, ranging from 1.3 for the most common cancer types (lung and breast) to slightly over 2.0 for the rarest (very radiosensitive sites). For Los Angeles County only, which contributed most of the cases for the combined analyses, there is only a slight elevation in the minimal detectable odds ratios. The power is not as great to detect differences for Ventura County, but odds ratios as low as 1.5 and no higher than 3.4 are still detectable by this study.

## SUMMARY

These follow-up analyses suggest that people living near the SSFL are not at increased risk for developing cancers associated with radiation exposure. Although, as discussed below, some

specific comparisons are statistically significant, the pattern of the elevations is not consistent with a community-wide environmental exposure to radiation.

## *Findings*

Very radiosensitive cancers are not significantly elevated or proportionately more common among either men or women in any of the time periods examined or geographical comparisons made. Among moderately radiosensitive cancers, breast cancer showed no association with geographic proximity to the SSFL and lung cancer showed considerable variability between the Ventura and Los Angeles County study areas, and between men and women. The higher rate of bladder cancer, noted in the preliminary report, was also observed in these analyses, although limited to men in Los Angeles County. These findings are discussed below, as are the findings for cancers with the least evidence for radiogenic causes.

1. ***Very Radiosensitive Cancers:*** There is no evidence to suggest that those types of cancer that would be most likely to have radiation exposure as a major contributing cause occurred more commonly among residents in either Ventura or Los Angeles County who live near the SSFL. Although this cancer group included relatively rare types of cancer, there appeared to be sufficient power in this study to detect elevations as modest as 57%. These data suggest that, if anything, the incidence of these cancers may actually have been lower among people living near the SSFL during the years covered.

2. ***Moderately Radiosensitive Cancers:*** Cancers of the female breast appeared to have occurred among women living near the SSFL at the same rate, and the same proportion, as these cancers occurred among non-Hispanic women elsewhere in Ventura and Los Angeles. For cancers of the lung, the pattern of occurrence was inconsistent. During the time periods examined, lung cancer did not occur at a higher rate or proportionately more often among either non-Hispanic White men or women who lived in the Los Angeles County area adjacent to the SSFL. In fact, women in this comparison showed significantly lower incidence rates of lung cancer than would be expected based on county-wide rates. However, lung cancer was proportionately more common among non-Hispanic White men, but not women, in the Ventura County area close to the SSFL.

3. ***Possibly Radiosensitive Cancers:*** During 1983-1988, possibly radiosensitive cancers occurred at a significantly higher rate among non-Hispanic White men who lived in the Los Angeles County area adjacent to the SSFL; rates were not elevated for them in the earlier time period or among their female counterparts in either time period. The majority of the increased rate in possible radiogenic cancers among these men appears to be associated with a non-significant elevation in bladder cancer, which accounts for the majority of possibly radiogenic cancers. This finding is consistent with the preliminary DHS report. It is also consistent with the proportional incidence analysis presented in this report which

shows that bladder cancer and possibly radiogenic cancers as a group occurred proportionately more often during 1988-89 among non-Hispanic White men living in the Los Angeles County area close to the SSFL, although neither of those associations is statistically significant. However, among non-Hispanic Whites in Ventura County, bladder cancer occurs proportionately less often among both men and women who live in the area close to the SSFL than in the rest of the county, and there is no elevation in the proportion of possibly radiogenic cancers as a group.

In evaluating these findings it is important to consider a number of factors which influence the likelihood that an environmental agent such as radiation could have an effect on differences in incidence. We would expect that if community exposure to ionizing radiation were causing an elevation in cancers in this geographic area we would see the greatest increase among those cancers known to be most strongly associated with radiation exposure. Not only is such a pattern not evident, but the very radiosensitive cancer group appears to be somewhat underrepresented among people living near the SSFL.

For those cancers which do show some elevation, cancers of the lung and bladder, there are two factors which argue against a general environmental agent. First, the pattern of elevation is inconsistent. If there were a general environmental cause for these cancers, we would expect the pattern of higher incidence to be shared by both men and women in the same geographic area, and to be consistent on both the Ventura and Los Angeles sides of the SSFL. Second, both lung and bladder cancer are known to be strongly associated with a number of causes other than radiation[8]. The leading risk factor for both cancers of the lung and bladder is smoking. Smokers have roughly 10 times the risk of non-smokers for lung cancer, and roughly twice the risk of non-smokers for bladder cancer. These are also both cancers for which increased risk has been demonstrated with a variety of occupational exposures. Higher lung cancer rates have been observed among workers exposed to such agents as asbestos, mustard gas, polycyclic hydrocarbons, chloromethyl ethers, chromium, nickel and inorganic arsenic. Higher bladder cancer rates have been observed among workers exposed to such agents as benzidine and 2-naphthylamine. Experts believe that more cases of both lung and bladder cancer can be attributed to tobacco exposure than to any other known cause.

## *Study Limitations*

These analyses were designed to use the available data on population-based cancer reporting in Ventura and Los Angeles Counties to assess whether or not there is evidence to suggest current elevations in the incidence of cancers thought to be associated with ionizing radiation among people

8 Schottenfeld D, Fraumeni JF. Cancer Epidemiology and Prevention. W. B. Saunders Co, Philadelphia, 1982.

living near the SSFL. As such, there are a number of limitations which should be considered in the interpretation of these data.

1. ***There is no information on exposure to radiation.***
   There is no way of telling, from these data, whether or not any individual case may or may not have actually had any occupational or environmental exposure to ionizing radiation above background. Although chosen to maximize the ability of this analysis to detect elevated cancers in populations near the SSFL, a five-mile radius is a weak surrogate for environmental exposure.

2. ***There is no information on other important exposures.***
   There are a number of other risk factors which are known to be associated with some of these cancers, for example smoking as a cause of lung cancer. There is no information from the cancer registry data on smoking or other lifestyle risk factors among the cases.

3. ***There is no follow-up of people who lived there years ago.***
   People with cancer were included in these analyses based on where they lived at the time they were first diagnosed with their disease. There is no information on how long, prior to diagnosis, they may have lived near the SSFL. Similarly, people who may have lived near the SSFL for many years and then moved away before being diagnosed with cancer would not be included in this study.

4. ***There is limited power to detect differences.***
   There is sufficient power, given the number of cancers available to study, to detect reasonably modest standardized incidence ratios and proportional incidence ratios. For some of the cancer types of special interest, however, such as very radiosensitive cancers and cancers of the urinary bladder, it is unlikely that these analyses would find risks lower than two-fold. It is therefore possible that some of the observed comparisons could be "false negatives", that is, reflective of truly higher risks that we could simply not detect because of limited numbers.

5. ***There are problems of multiple testing.***
   Because these analyses looked at a number of comparisons -- by cancer group, by geographic area and by sex -- there is a greater probability of finding a "statistically significant" association (either higher or lower than expected) by chance alone even if living near the SSFL had no effect. It is therefore possible also that some of the observed comparisons that appear to be high (or low) could be "false positives", that is, not really higher (or lower) than would be expected.

## *Conclusions*

These analyses were designed to maximize the ability to find differences which may exist, and minimize the problem of finding spurious differences due to multiple testing. Nevertheless, it is evident that because of the rarity many of the cancer types of interest these data are very limited. It is quite possible that, because of the limitations of available data, true risk associations may have been missed and observed risk associations may be a function of chance. It is important, however, even given limitations of method, that the apparent excesses observed in these analyses be taken into consideration as epidemiologic studies are undertaken ay Rocketdyne.

The two cancer types (bladder and lung) that appear to be in excess from these analyses among men, but not necessarily among women, are cancers for which there is some good evidence for occupationally-associated risks. These are also both cancers for which smoking is a very strong risk factor.

Funding is now available from the Department of Energy to pursue an epidemiologic study of worker health among current and former Rocketdyne employees. It is important to evaluate the degree to which the observed excesses in these data might be a function of occupational or lifestyle, as opposed to environmental, exposures.

TABLE 1. DISTRIBUTION OF STUDY CANCER TYPES IN LOS ANGELES COUNTY NEAR THE SANTA SUSANA FIELD LABORATORY*, 1978-1988

| | 1978-82 | | 1983-88 | |
|---|---|---|---|---|
| Type of Cancer | Males | Females | Males | Females |
| *Very Radiosensitive* | *23* | *24* | *26* | *34* |
| Leukemias (excl. CLL) | 15 | 13 | 17 | 16 |
| Bone | 1 | 0 | 3 | 5 |
| Thyroid | 7 | 11 | 6 | 13 |
| *Moderately Radiosensitive* | | | | |
| *Female Breast* | - | *199* | - | *297* |
| *Lung* | *112* | *51* | *156* | *118* |
| *Possibly Radiosensitive* | *104* | *49* | *144* | *71* |
| Stomach | 15 | 7 | 20 | 16 |
| Esophagus | 3 | 2 | 14 | 6 |
| Liver | 2 | 1 | 6 | 3 |
| Brain | 15 | 14 | 21 | 7 |
| *Bladder* | *48* | *11* | *57* | *22* |
| Other Urinary org. | 11 | 8 | 18 | 14 |
| Parathyroid | 0 | 0 | 0 | 0 |
| Salivary gland | 4 | 1 | 0 | 0 |
| Multiple myeloma | 6 | 5 | 8 | 3 |

* Invasive cancers among non-Spanish surname Whites residing in one of the following census tracts at the time of diagnosis: 1132, 1343, 1344, 1351, 1352.

TABLE 2. STANDARDIZED INCIDENCE RATIOS AND 95% CONFIDENCE INTERVALS FOR STUDY CANCERS IN LOS ANGELES COUNTY NEAR THE SANTA SUSANA FIELD LABORATORY*, 1978-1988

| 1978-1982 Type of cancer | Males SIR (95% CI) | Females SIR (95% CI) |
|---|---|---|
| Very Radiosensitive† | 112.5 ( 71.3-168.8) | 97.2 ( 62.3-144.7) |
| Moderately Radiosensitive | | |
| Female Breast | -- | 108.1 ( 93.6-124.2) |
| Lung | 95.5 ( 76.8-114.9) | 74.8 ( 55.7- 98.4) |
| Possibly Radiosensitive‡ | 103.0 ( 84.2-124.8) | 87.6 ( 64.8-115.8) |
| Bladder | 128.6 ( 94.8-170.5) | 77.3 ( 38.6-138.3) |

| 1983-1988 Type of cancer | Males SIR (95% CI) | Females SIR (95% CI) |
|---|---|---|
| Very Radiosensitive† | 109.8 ( 71.7-160.8) | 109.8 ( 76.1-153.4) |
| Moderately Radiosensitive | | |
| Female Breast | -- | 109.0 ( 96.9-122.1) |
| Lung | 112.4 ( 95.5-131.5) | 119.3 ( 98.7-142.8) |
| Possibly Radiosensitive‡ | 124.9 (105.3-147.1) | 109.4 ( 85.5-138.0) |
| Bladder | 132.6 (100.5-171.9) | 140.0 ( 87.8-212.0) |

* Ratios for non-Spanish surname Whites residing in one of the following census tracts at diagnosis: 1132, 1343, 1344, 1351, 1352.

† Includes leukemia (except CLL), thyroid and bone.

‡ Includes stomach, esophagus, liver, brain, bladder and other urinary organs, parathyroid, salivary gland, and multiple myeloma.

TABLE 3. DISTRIBUTION OF STUDY CANCER TYPES IN VENTURA AND LOS ANGELES COUNTIES NEAR THE SANTA SUSANA FIELD LABORATORY*, 1988-1989

| Type of Cancer | Ventura | | Los Angeles | |
|---|---|---|---|---|
| | Males | Females | Males | Females |
| *Very Radiosensitive* | *2* | *7* | *6* | *13* |
| Leukemias (excl. CLL) | 0 | 1 | 1 | 0 |
| Bone | 2 | 0 | 1 | 0 |
| Thyroid | 0 | 6 | 4 | 13 |
| *Moderately Radiosensitive* | | | | |
| *Female Breast* | - | *77* | - | *202* |
| *Lung* | *49* | *24* | *83* | *72* |
| *Possibly Radiosensitive* | *32* | *12* | *74* | *39* |
| Stomach | 4 | 4 | 13 | 7 |
| Esophagus | 4 | 0 | 8 | 4 |
| Liver | 3 | 0 | 1 | 3 |
| Brain | 9 | 4 | 8 | 4 |
| *Bladder* | *10* | *2* | *33* | 14 |
| Other Urinary org. | 0 | 0 | 1 | 1 |
| Parathyroid | 0 | 0 | 0 | 0 |
| Salivary gland | 0 | 0 | 0 | 1 |
| Multiple myeloma | 2 | 2 | 10 | 5 |

* Invasive cancers among non-Hispanic Whites residing in one of the following census tracts at the time of diagnosis: Los Angeles tracts 1131, 1132.01, 1132.02, 1132.03,1133.02, 1133.03, 1134.02, 1342.01, 1343.01, 1343.02, 1343.03, 1344.01, 1344.02, 1345, 1351.01, 1351.02, 1352.01, 1352.02, 1352.03, 1372.01, 1372.02, 1373.01, 1373.02, 1373.03, 8002, 8003.01, or 9203.03; Ventura tracts 74.01, 75.02, 75.03, 79, 80.01, 80.02, 80.03, 81, 82, 83.01, 83.02, 84.01, 84.02 or 85.

TABLE 4. PROPORTIONAL INCIDENCE RATIOS AND 95% CONFIDENCE INTERVALS FOR STUDY CANCERS NEAR THE SANTA SUSANA FIELD LABORATORY*, 1988-1989

| Type of cancer | Males Odds Ratio (95% CI) | Females Odds Ratio (95% CI) |
|---|---|---|
| Very Radiosensitive† | 0.87 (0.42-1.79) | 1.00 (0.62-1.60) |
| Moderately Radiosensitive | | |
| Female Breast | -- | 1.04 (0.90-1.22) |
| Lung | 1.10 (0.90-1.33) | 0.96 (0.77-1.19) |
| Possibly Radiosensitive‡ | 1.25 (1.01-1.55) | 1.05 (0.79-1.41) |
| Bladder | 1.11 (0.81-1.52) | 1.20 (0.73-1.99) |

* Odds ratios for non-Hispanic Whites residing in one of the following census tracts at the time of diagnosis: Los Angeles tracts 1131, 1132.01, 1132.02, 1132.03, 1133.02, 1133.03, 1134.02, 1342.01, 1343.01, 1343.02, 1343.03, 1344.01, 1344.02, 1345, 1351.01, 1351.02, 1352.01, 1352.02, 1352.03, 1372.01, 1372.02, 1373.01, 1373.02, 1373.03, 8002, 8003.01, or 9203.03; Ventura tracts 74.01, 75.02, 75.03, 79, 80.01, 80.02, 80.03, 81, 82, 83.01, 83.02, 84.01, 84.02 or 85.

† Includes leukemia (except CLL), thyroid and bone.

‡ Includes stomach, esophagus, liver, brain, bladder and other urinary organs, parathyroid, salivary gland, and multiple myeloma.

TABLE 5. PROPORTIONAL INCIDENCE RATIOS AND 95% CONFIDENCE INTERVALS FOR STUDY CANCERS IN VENTURA AND LOS ANGELES COUNTIES NEAR THE SANTA SUSANA FIELD LABORATORY*, 1988-1989

| Ventura County<br>Type of cancer | Males<br>Odds Ratio (95% CI) | Females<br>Odds Ratio (95% CI) |
|---|---|---|
| Very Radiosensitive† | 0.32 (0.06-1.62) | 0.66 (0.28-1.54) |
| Moderately Radiosensitive | | |
| Female Breast | -- | 1.13 (0.83-1.53) |
| Lung | 1.66 (1.17-2.37) | 0.80 (0.51-1.26) |
| Possibly Radiosensitive‡ | 1.23 (0.82-1.84) | 0.77 (0.41-1.44) |
| Bladder | 0.85 (0.44-1.64) | 0.44 (0.11-1.74) |
| **Los Angeles County<br>Type of cancer** | **Males<br>OR (95% CI)** | **Females<br>OR (95% CI)** |
| Very Radiosensitive† | 1.17 (0.52-2.66) | 1.05 (0.59-1.85) |
| Moderately Radiosensitive | | |
| Female Breast | -- | 1.04 (0.87-1.24) |
| Lung | 0.94 (0.74-1.19) | 0.99 (0.77-1.27) |
| Possibly Radiosensitive‡ | 1.26 (0.98-1.61) | 1.11 (0.80-1.55) |
| Bladder | 1.20 (0.84-1.73) | 1.44 (0.84-2.46) |

* Odds ratios for non-Hispanic Whites residing in one of the following census tracts at the time of diagnosis: Los Angeles tracts 1131, 1132.01, 1132.02, 1132.03, 1133.02, 1133.03, 1134.02, 1342.01, 1343.01, 1343.02, 1343.03, 1344.01, 1344.02, 1345, 1351.01, 1351.02, 1352.01, 1352.02, 1352.03, 1372.01, 1372.02, 1373.01, 1373.02, 1373.03, 8002, 8003.01, or 9203.03; Ventura tracts 74.01, 75.02, 75.03, 79, 80.01, 80.02, 80.03, 81, 82, 83.01, 83.02, 84.01, 84.02 or 85.

† Includes leukemia (except CLL), thyroid and bone.

‡ Includes stomach, esophagus, liver, brain, bladder and other urinary organs, parathyroid, salivary gland, and multiple myeloma.

TABLE 6. POWER ESTIMATES - LOWEST STANDARDIZED INCIDENCE RATIOS* DETECTABLE FOR STUDY CANCERS IN LOS ANGELES COUNTY NEAR THE SANTA SUSANA FIELD LABORATORY, 1978-1988

| 1978-1982 Type of cancer | Males Lowest Detectable SIR | Females Lowest Detectable SIR |
|---|---|---|
| Very Radiosensitive† | 172 | 164 |
| Moderately Radiosensitive | | |
| Female Breast | -- | 122 |
| Lung | 128 | 137 |
| Possibly Radiosensitive‡ | 130 | 141 |
| Bladder | 151 | 188 |

| 1983-1988 Type of cancer | Males Lowest Detectable SIR | Females Lowest Detectable SIR |
|---|---|---|
| Very Radiosensitive† | 166 | 157 |
| Moderately Radiosensitive | | |
| Female Breast | -- | 118 |
| Lung | 125 | 130 |
| Possibly Radiosensitive‡ | 128 | 138 |
| Bladder | 147 | 183 |

* Lowest detectable standardized incidence ratio for this data set, given (two-sided) alpha=.05 and 1-beta=.80, and using the method described in Armstrong B, "A simple Estimator of Minimum Detectable Relative Risk, Sample Size, or Power in Cohort Studies," Amer. J. Epidemiol. 126(2):356-358, 1987.

† Includes leukemia (except chronic lymphocytic), thyroid and bone.

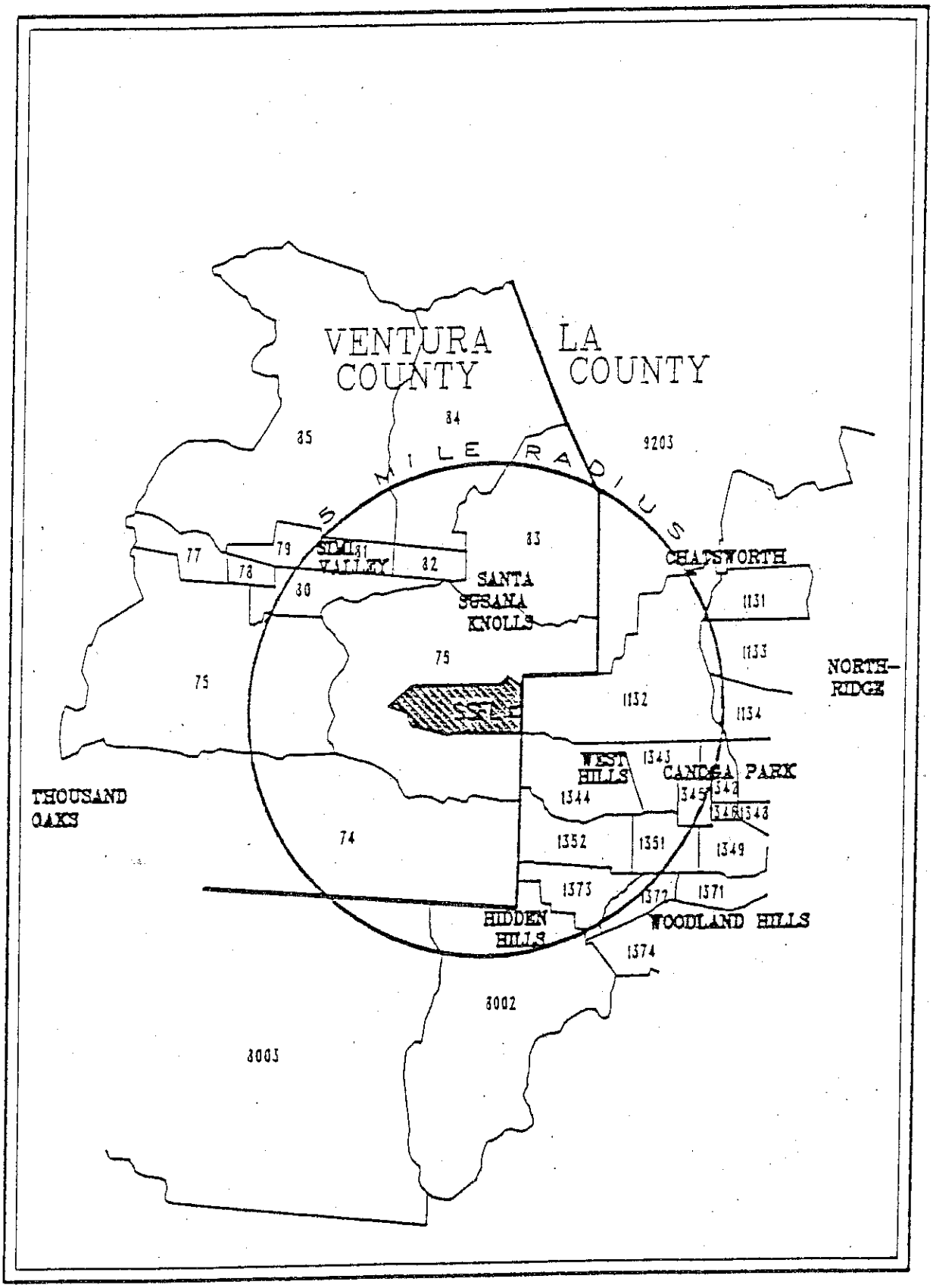
‡ Include stomach, esophagus, liver, brain, bladder and other urinary organs, parathyroid, salivary gland and multiple myeloma.

TABLE 7. POWER ESTIMATES - LOWEST PROPORTIONAL INCIDENCE RATIOS* DETECTABLE IN THIS STUDY BY CANCER TYPE AND GEOGRAPHIC AREA

| Type of Cancer | Geographic Area | | |
|---|---|---|---|
| | Ventura and LA | Ventura Only | LA Only |
| MALES | | | |
| Very Radiosensitive | 2.15 | 3.44 | 2.37 |
| Lung | 1.27 | 1.66 | 1.36 |
| Possibly Radiosensitive | 1.35 | 1.71 | 1.43 |
| Bladder | 1.51 | 2.03 | 1.61 |
| FEMALES | | | |
| Very Radiosensitive | 1.79 | 2.45 | 1.98 |
| Breast | 1.26 | 1.50 | 1.26 |
| Lung | 1.32 | 1.67 | 1.37 |
| Possibly Radiosensitive | 1.43 | 1.98 | 1.52 |
| Bladder | 1.82 | 2.93 | 2.02 |

* Lowest detectable approximate relative risk for this data set, given alpha=.05 and 1-beta=.80, and using the method described by Oliphant TH and McHugh RB, "Least significant relative risk determination in the case of unequal sample sizes", Amer. J. Epidemiol. 113(5):711-715, 1981.

MAP 1. CENSUS TRACTS WITHIN A FIVE MILE RADIUS OF THE SANTA SUSANA FIELD LABORATORY (1980)



MAP 2. CENSUS TRACTS WITHIN A FIVE MILE RADIUS OF THE SANTA SUSANA FIELD LABORATORY (1980 WITH SPLIT TRACTS)