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## **REPORT SUMMARY**

# **CASE-REFERENT STUDY OF CHILDHOOD LEUKEMIA IN MARICOPA COUNTY, ARIZONA 1965-1990**

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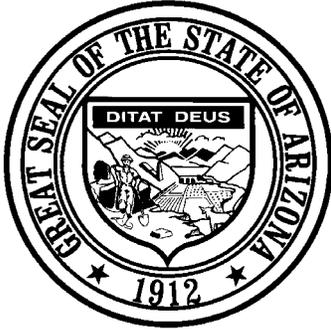
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## **DEDICATION**

To the children who experienced leukemia and to their families and friends also impacted by the illness.

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## **ABSTRACT**

**Objective.**—To determine whether exposure to specific environmental and personal factors was associated with the occurrence of childhood leukemia.

**Background.**—A previous study observed that 49 cases occurred in west central Phoenix (WCP) in the 21 years between 1965 and 1986. An expected number of cases for that time period based on rates from the rest of Maricopa county was 29 cases. Because of continued concerns, the current study expands the time period to include cases diagnosed through 1990 and cases diagnosed throughout Maricopa county.

**Design.**—Retrospective, case-referent study utilizing telephone administered questionnaires. Factors of concern included residential proximity to local sources of environmental contamination (wells and airborne emissions), and parent's and child's exposures to a broad range of factors. Samples of air, dust, and soil also were analyzed from selected homes in which parents still lived since the child's diagnosis date.

**Setting.**—Population based study conducted by the state health department in Maricopa county, Arizona's most populous county.

**Subjects.**—Parents of 222 children under 20 years of age when diagnosed with leukemia between 1965 and 1990; parents of 219 age- and gender-matched referents obtained from random digit dialing. The study has a nested investigation of 23 cases from WCP.

**Main outcome measure.**—Odds ratios (OR) seeking a link between leukemia and exposure.

**Results.**—Of the 413 eligible cases countywide, 222 (54%) participated. The number of participating cases from WCP was 23 of 58 eligible cases (40%). This low number of cases precluded the study from quantifying risk factors among cases only from WCP. The focus of the study was expanded to include cases from all of Maricopa county. The retrospective nature of the study limited its ability to quantify exposures to all possible environmental factors.

There was no difference between the group of cases and referents in their residential proximity to contaminated public wells, Superfund sites, state-defined areas of contamination, and most sources of airborne industrial chemical emissions. Of the many other factors we assessed (e.g., solvents, pesticides, occupation and industry, radiation, maternal characteristics, traffic density, and levels of chemicals measured in selected homes) most were not found to be statistically significant risks. However, living within 3 or 5 miles of a large, gasoline storage facility was a significant risk factor (OR=2.1; p=.03). But, there is little environmental data to suggest that living within that distance has led to chemical exposure. Exploratory analyses also revealed a risk associated with model building (OR=2.1; p<.05) in the home; child's use of black and white TV (OR=1.5; p=.04), father's hobby of car repair (OR=1.6; p=.03); and child's use of non-prescribed vitamins (OR=1.6; p=.02). There also was a statistically significant risk associated with father's cigarette smoking between the child's birth date and diagnosis date (OR=1.5; p=.03), any parent smoking (OR=1.5; p=.03), but not mother's smoking (OR=1.2; p=.37). Parental smoking of cigar or pipe showed risks similar to that of cigarettes.

**Conclusion.**—Chemical contaminants in the external environment, in general, were not linked to the occurrence of childhood leukemia in Maricopa county. A weak association of living near the gasoline storage facility warrants further evaluation of emissions. Cigarette smoking by the father or either parent was a weak risk factor for the development of childhood leukemia. The reason or reasons for the elevated number of leukemia cases from WCP observed between 1965 and 1986 was not specifically identified in this study.

## **PREFACE**

The Arizona Department of Health Services has undertaken this study in response to public concerns that environmental factors may have contributed to the occurrence of leukemia in children, particularly children residing in west central Phoenix (WCP). We designed the study to address the concerns expressed by residents of WCP, but we also considered the concerns of persons residing in other areas of Maricopa county. In addition, we designed the study to address many of the factors in the medical literature reported to be associated with leukemia.

We believe that this study fairly addresses the public's concerns by evaluating the environmental factors to the best degree available in a retrospective study and determining whether or not they are associated with the group of cases compared with a group of "referents."

Several times in this report we will note that the analysis compares the experience of the two groups. Our description of the experience of a group is really a composite of the experiences of individuals. However, these individual experiences sometimes differ markedly from that of the group as a whole.

Some parents may read this report expecting to discover the cause of their child's leukemia. Such an expectation will not be met in this report because of its focus on the group's experience.

A major intent of this study is to add to scientific knowledge about the causes of childhood leukemia. We also hope that the information will be helpful to the many parents who may have wondered about the factors that we studied. We are particularly grateful to the families that participated in this study, even though at times it may have brought back distressing memories. Through the participation of affected families and referent families, we gain knowledge about leukemia and its causes. It is our hope that the information reported herein will bring us closer to identifying the causes of leukemia and preventing cases in the future.

Funding for the study came from an appropriation of the Arizona Legislature and a grant from the federal Centers for Disease Control and Prevention.

# GLOSSARY

(Abbreviations, jargon, and various terms)

<b>TERM</b>	<b>EXPLANATION</b>
ACR	<b>A</b> rizona <b>C</b> ancer Registry, a program of the <b>A</b> rizona <b>D</b> epartment of <b>H</b> ealth <b>S</b> ervices (ADHS)
ALL	<b>a</b> cute <b>l</b> ymphocytic leukemia
AML	<b>a</b> cute <b>m</b> yeloid leukemia (includes acute myelocytic or myelogenous leukemia)
ANLL	<b>a</b> cute <b>n</b> onlymphocytic leukemia; this includes AML
case	a child who developed leukemia (see referent)
case-referent study	also known as a case-control study; a study that compares the experience of a group of cases with a similar group known as the "referents" or "controls".
cr or C/R	the statistical code for the leukemia status of the subjects; cases are coded as "1" and referents are coded as "0".
DOT	<b>D</b> ictionary of <b>O</b> ccupational <b>T</b> itles, a publication of the US Department of Labor.
freq.	frequency; the count of the number of subjects
geo-code	the geographic position, that is, the latitude and longitude of a point on the earth's surface
index child	this refers to either the case-child that had leukemia or the matching referent-child
lop-sided p-value	an adjusted p-value that takes the direction of the results (expected vs not expected) into account; we consider a lop-sided p-value of less than .05 to be statistically significant.
LNMP	<b>l</b> ast <b>n</b> ormal <b>m</b> enstrual <b>p</b> eriod of the mother (this signifies the start date of the child's prenatal life)
NCI	<b>N</b> ational <b>C</b> ancer <b>I</b> nstitute (a federal agency)
OR	odds ratio, derived from a 2X2 table
OSHA	<b>O</b> ccupational <b>S</b> afety and <b>H</b> ealth <b>A</b> dministration (a federal agency)
p or p-value or Pr	The probability that a finding could be attributed to chance. Probabilities less than 5% ( $p < 0.05$ ) are generally considered unlikely to have occurred by chance.
RCQ	<b>R</b> esidential <b>C</b> haracteristics <b>Q</b> uestionnaire
referent	a child who does not have the disease on the reference date; many studies call such subjects "controls"
ref date	<b>r</b> eference date, that is, the date of diagnosis for the case; for a referent it is the date at which he or she was the same age as his/her matched case.
SIC77 code	<b>S</b> tandard <b>I</b> ndustrial <b>C</b> lassification code (1977 version) of the industry title
SOC code	<b>S</b> tandard <b>O</b> ccupational <b>C</b> lassification code of the job title
statistically significant	a mathematical determination that a distribution of numeric values is unlikely to have occurred by chance
WQARF	<b>W</b> ater <b>Q</b> uality <b>A</b> ssurance <b>R</b> evolving <b>F</b> und (an Arizona program to investigate and clean-up contaminated sites)
WCP	<b>w</b> est <b>c</b> entral <b>P</b> hoenix, the area that had an elevated rate of leukemia among children between 1965-1986.

# **SUMMARY**

## **CASE-REFERENT STUDY OF CHILDHOOD LEUKEMIA IN MARICOPA COUNTY, ARIZONA, 1965-1990**

This summary condenses the full, 280-page document.

### **INTRODUCTION**

This is a case-referent study of children diagnosed with leukemia between 1965 and 1990. The study was conducted by the Arizona Department of Health Services (ADHS) in response to public concerns that environmental factors might have led to the occurrence of leukemia in children. The study includes participants (cases and referents) from west central Phoenix and all of Maricopa county.

### **BACKGROUND**

In 1982 a parent first identified an elevated number of children with leukemia attending a school in west central Phoenix. An evaluation by ADHS at that time did not reveal any unusual environmental factors. Public concerns resurfaced in 1987, leading to two ADHS studies that addressed overall death rates and childhood cancer incidence rates in Maricopa county and west central Phoenix (WCP, defined here as the 50 square mile area from 27th Avenue to 83th Avenue, and Camelback Road to Southern Avenue). The ADHS reported the results of those two studies in 1988 and 1990. The incidence study showed an elevation of the rate of leukemia in WCP among children 0-19 years of age: whereas 29 new cases in WCP would have been expected to occur between 1965 and 1986, in actuality 49 cases were observed in that time period. The only leukemia subtype that was elevated in WCP was acute myeloid leukemia (AML), an uncommon subtype in children.

As a result of those studies the community urged the ADHS to proceed with this case-control study to search for an explanation for the elevation, especially to look for a link to environmental factors.

Meanwhile, an updated calculation of childhood leukemia incidence rates, using cases diagnosed 1987-1990, showed that the number of new leukemia cases in WCP did not exceed the expected number based on the Maricopa county rate in that time period.

### **STUDY AIMS**

The purpose of this case-referent study (also called a case-control study) was to investigate possible risk factors for childhood leukemia in Maricopa County with a primary focus on the factors that might have produced the elevated childhood leukemia rate in WCP. The lack of known causes of leukemia presented fundamental difficulties for our study. Because the cause of leukemia is basically unknown, we looked broadly for possible risk factors. In general terms, the primary objectives were as follows:

- C To characterize the association of residence in WCP with the occurrence of childhood leukemia.
- C To assess whether the residence of cases tended to cluster around local sources of environmental exposure.

- C To determine if the risk for childhood leukemia was associated with exposure to pesticides, solvents, and petroleum products. Exposure was evaluated by two methods: a questionnaire and limited environmental sampling of household environments.

Secondary objectives were:

- C To determine if there was an association of childhood leukemia with other known or suspected risk factors, such as ionizing radiation, genetic and familial factors, traffic volume, cigarette smoke, drugs, electric and magnetic fields (EMF), and migration patterns.

## **METHODS**

We collected information from questionnaires administered over the telephone to the parents of cases and referents. Completion of the questionnaires took an average of 42 minutes for fathers and 75 minutes for mothers. In addition, parents were asked to provide complete residential histories, and to document the characteristics of the homes in which they had lived. Also, in a limited number of homes, we collected samples of indoor air, soil, and household dust, and we measured the strength of magnetic fields.

## **PARTICIPANTS**

A "case" was defined as a child, age 0-19, who resided in Maricopa county when diagnosed with leukemia during the period 1965-1990. The list of such cases was obtained from the Arizona Cancer Registry.

Of 413 eligible cases of leukemia there were 274 for whom we located at least one parent and requested their participation. Of these, the parents of 222 cases (81% of the 274 locatable; 54% of the 413 eligible) actually participated in our study. These 222 participating cases were compared to 219 age- and gender-matched referents, whom we selected by using random digit dialing of telephone numbers in Maricopa county.

The participation rate of case families living in WCP when diagnosed with leukemia was lower than the rate of participation just described for all cases. Of 58 eligible cases registered from WCP, there were 36 families located. Of these, the parents of 23 cases (64% of the 36 locatable; 40% of the 58 eligible) actually participated.

The general characteristics of the cases and referents (actually their parents) were very similar with respect to race and ethnicity, income, education level, and the participation by a father and mother. However, there was a major difference in the vital status of their child: none of 219 child-referents were known to have died, whereas 102 of the 222 child-cases had died when the parents were interviewed.

We formulated *a priori* one or more hypotheses for each objective listed above.

## **STATISTICAL ANALYSIS**

The analyses and results in the full report are lengthy, complex, and difficult to summarize. For most analyses the results are presented as 2X2 tables, with the calculation of an odds ratio (OR), p-value, and a 95% confidence interval. A p-value less

than 0.05 is considered statistically significant. Where we suspected the results would most likely fall into one of the tails of a two-sided chi-square test we used the lopsided p-value. If we were concerned only about one outcome then we used one-sided tests for significance. Logistic regression was used often. Because many of the questions quantified events of interest, we assessed the frequency of many items. Hundreds of significance tests were performed in this analysis. For each group of related factors, our approach was to look for a difference in levels of each factor among cases and referents. In those situations where it seemed warranted, we then went on to consider whether the different level was expressed more strongly in WCP than outside that area.

For the methods and definitions of how the hypotheses were tested we refer the reader to the full report.

## **RESULTS**

In this summary section, when we say “no difference” we mean that we found “no statistically significant difference between the group of cases and the group of referents.” That is to say, unless we note otherwise, any difference that we found (either a risk or protection) could be attributed to chance.

To place our analysis into the context of the previous incidence study, we determined the proportion of cases who were living in WCP when diagnosed with leukemia compared to the proportion of referents who were living in WCP on that date. The proportion of cases with leukemia from WCP was elevated (compared to the proportion of referents without leukemia from WCP), but this difference was not statistically significant. One reason for this finding may be the low participation rate of cases from WCP, leading to a lack of statistical power. Nevertheless, the odds ratio showed a non significant risk of 1.37, a figure consistent with our finding in the incidence study.

We summarize the results of other hypotheses as follows:

### **1. Living in WCP**

#### **a. Residence in WCP among those in WCP on the reference date**

There was no difference between cases and referents in the proportion of subjects who were born in WCP. There was no difference in the proportion of time the subjects had lived in WCP. There was no difference in the length of time spent in WCP prior to being diagnosed.

#### **b. Residence in WCP among those not in WCP on the reference date**

There was no difference between the cases and referents in the proportion who had spent any time in WCP. There was no difference in the lifetime fraction spent in WCP.

#### **c. Birth in WCP**

There was no difference between the cases and referents in the proportion of children diagnosed by 5 years of age who were born in WCP. There also was no difference in the proportion of participants age 0-19 who were born in WCP.

#### **d. Age at diagnosis and birth in WCP**

There was statistically significant evidence that children diagnosed before 60 months of age and born in WCP were diagnosed at an older age than those born

outside WCP. We interpret this finding as evidence against the hypothesis that there may have been a prenatal risk factor in WCP. However, we offer no explanation for this finding.

In summary, the proportion of cases and referents who shared various attributes related to living in WCP was statistically similar. There was no clear evidence that being born in, nor living in, WCP was a risk factor for developing childhood leukemia. A test that looked at the age at diagnosis of young children with leukemia who had been born in WCP showed that, in fact, their leukemias were diagnosed at later ages than those born outside WCP. We doubt that this difference could be attributed to differences in access to health care. We interpret this as indirect evidence that a factor to which cases could have been exposed prenatally or in infancy did not exist.

A visual display (placement of dots on a map) of the lifetime residential locations of the cases and referents does not reveal any obvious clustering.

The data about residential history in WCP did not provide us with a clear direction to look for a possible cause of the elevation noted in the incidence study, nor a clear direction for a cause of leukemia in general. Further, the number of cases that had been diagnosed while living in WCP, or had ever lived in WCP, was too small to justify a primary, separate analysis of WCP for the remainder of the hypotheses. However, for statistically significant findings we did look separately at WCP.

Unless noted otherwise, the following statements do not specifically refer to participants only from WCP, but rather, they refer to the analysis of cases and referents countywide.

## **2. Emissions and pollution of the general environment**

In this section we addressed the items that the public suspected as linked to the cases.

### **a. Public wells with contaminants**

The chemical trichloroethylene (TCE) has been identified as the most common contaminant of public wells. Our study finds that residence within 0.5, 1.0, or 2.0 miles of municipal wells contaminated at levels above the allowable, maximum contaminant level (MCL) in Maricopa county was not a leukemia risk factor to the subjects participating in the study. Consideration of specific exposure windows, namely, the date of the mother's last normal menstrual period [LNMP] to the child's birth date; birth date to initiation date (a hypothetical date when the leukemia may have been triggered); and initiation date to diagnosis date also did not reveal that exposure to wells was a risk factor.

### **b. Gasoline tank storage facility**

Having lived within 3 miles of the Tank Farm was a significant risk factor (odds ratio 2.2; lower 95% confidence bound, 1.04). No participants had lived within one mile; the odds ratio for having lived within two miles was 1.8. Living within 5 miles, but not 4 miles, also was a risk factor. Living in proximity to the Tank Farm was a stronger risk factor for leukemia than simply living within the boundaries of WCP.

### **c. Proximity to Superfund sites**

Residence within the boundaries of one or more federal, EPA-defined, Superfund

areas in the county during the period between birth and diagnosis was not a risk factor.

- d. Water Quality Assurance Revolving Fund (WQARF) sites  
Residence within 0.5, 1.0, or 2.0 miles of any WQARF site, as defined by the Arizona Department of Environmental Quality, was not a risk factor.
- e. Airborne chemical emissions  
Residence within 0.5, 1.0, or 2.0 miles of any one of 162 different sources of airborne volatile organic chemicals in Maricopa county was not a risk factor. Proximity to gas stations was analyzed separately, and also showed no risk associated with living within 200 feet or 200 yards of a station.

### 3. Solvent exposure

#### a. Parent's Job

##### i. Exposure inferred from the parent's job title and industry

We defined exposure by using solvent exposure codes developed for occupational studies by the National Cancer Institute. These codes considered the probability and intensity of exposure to solvents. Our results showed no association with the jobs of the mother or father. Neither the time from birth to diagnosis, nor the time from the mother's last normal menstrual period (LNMP) to birth showed any association. Also, we found no increased risk associated with occupational exposure to "solvents" as a group, nor to any one of 11 individual solvents.

##### ii. Self-reported job exposure to specific solvents

There was little or no difference in the exposure to specific solvents. Use of the solvent TCE was remembered by parents of 24 cases and 15 referents; however, this finding was not statistically significant.

##### iii. Exposure inferred from use of protective clothing

Neither wearing protective clothing while exposed to solvents, nor wearing the clothing home was associated with case/referent status.

#### b. Household exposure through hobbies

Measurement of exposure relied upon the parents' recall of 10 specific activities. Two findings were significant. For the analysis of the household, the data suggest that model building (OR 1.9; 95% CI 1.1 to 3.4; p=0.02) was a risk factor, and that use of large power tools (OR 0.33; 95% CI 0.17 to 0.66; p=0.002) was a protective factor. ("Protective" factors are the opposite of "risk" factors. That is, protective factors are associated with a **lower** risk for leukemia.) The "father only" analysis indicated automobile/truck repair (OR 1.6; 95% CI 1.03 to 2.50; p=0.033) as the only significant risk factor. The elevated risk was not linked to residents of WCP, nor to acute myeloid leukemia (AML).

#### c. Inferred exposure from residential characteristics and activities

We assessed various questions about the residential characteristics (for example, cars, parking, garages, gas oven, type of heating and cooling, storing of paints and gasoline powered vehicles). Only two items were related to leukemia status of the participants. Parking the car in a lot 100 feet from the residence was protective (OR 0.85;  $p=0.047$ ). Children who spent less than an hour per day outdoors seemed at increased risk (OR 1.23;  $p=0.044$ ).

d. Inhalation of various substances to get “high”

Too few participants (cases or referents) reported exposure to this factor to assess its impact.

#### 4. Pesticides

a. Parent’s Job

i. Exposure inferred from the parent's job title and industry

We inferred exposure through the use of pesticide exposure codes developed by the National Cancer Institute for occupational studies . These codes took the probability and intensity of exposure to pesticides into account. Our results showed no association with the jobs of the mother or father. Neither the time span from birth to diagnosis, nor the span from mother’s last normal menstrual period to birth showed any association.

ii. Self-reported job exposure to specific pesticides

There was little difference between the cases and referents as to their overall exposures. Too few participants recalled exposure to specific pesticides for meaningful analysis.

iii. Exposure inferred from use of protective clothing on the job

Too few participants utilized protective clothing in the setting of pesticide exposure to assess its role.

b. Household Pesticide Use

After extensive analysis, only the use of liquid concentrate against ants and cockroaches was of significance (OR 3.3;  $p=.036$ ). However, the use of sprays against these pests was much more common, but was not significant. Furthermore, neither self-applied pesticides nor professional application against these pests was a risk factor. This lack of internal consistency weakens the evidence concerning about household pesticides.

c. Potential neighborhood exposure: See #5 below.

d. Skin-applied insect repellent

Use of mosquito repellants was unrelated to leukemia status.

#### 5. Industries recalled near the home

Many items in this extensive section were found to be statistically significant, with odds ratios around 2.0. Industries that had higher odds ratios at 0.5 miles than at

2 miles were: Agricultural (crops production, including commercial orchards); Agricultural (livestock production); Auto repair, services and garages; Utilities: electric, gas, and sanitary services; Machinery manufacturing; and Transportation by air (excluding military airports). For several reasons we attributed these findings to recall bias: the subjective nature of the questions; the cases tended to recall living closer to every item we asked about; the odds ratios were weak; and there was lack of consistency using more objective measurements of proximity to various industries (described above in 2e).

## **6. Radiation**

### **a. Childhood Exposure to Radiation**

There was little or no evidence that any childhood radiation exposure was related to case/referent status in this study. This was true whether exposure was scored present/absent, or based on a count of exposures. There also was no evidence of a relationship between total exposures over all the categories (e.g., chest x-ray, broken bone) and case/referent status.

### **b. Maternal Radiation Exposure**

There were very few reports of radiation exposures, which had the effect of limiting the power of the analysis. None of the radiation exposures appeared related to case/referent status. Moreover, there also appeared to be no relationship between the total number of exposures (regardless of type) and case/referent status.

### **c. Exposure inferred from use of a radiation monitoring badge**

Few participants stated that they wore such a badge. We found no association with the wearing of a badge and case/referent status.

### **d. Exposure inferred from the parent's job title and industry**

This indirect measure of exposure showed no significant associations with specific jobs or industries.

## **7. Family medical history**

There was no evidence of kindred intermarriage among the parents of the cases compared to the referents. After adjusting for multiple comparisons, there was no evidence of an excess of birth defects among cases or referents. Nevertheless, without this adjustment there was evidence among the parent's offspring (the index child or a sibling) of an increased occurrence of various skeletal abnormalities that could be associated with genetic syndromes (countywide: 10 case families, 2 referent families), and the trisomy Down syndrome (countywide: 7 case families, 1 referent family). Five case-children had Down syndrome, siblings in two case-families had Down Syndrome. Other published studies of persons with leukemia also have found that Down syndrome is a strong risk factor for leukemia.

There was no evidence that cancer or leukemia occurred more often among the parents or grandparents of the cases or the referents. That is to say, the childhood leukemia cases did not occur among "cancer prone" families.

## **8. Vehicular traffic**

### **a. Proximity of traffic to residence**

We used the residential addresses to model the exposure to exhausts of vehicular traffic across three decades. However, there was no evidence that traffic volume in Maricopa county was related to case status.

### **b. Commuting to school**

The time spent in commuting (a source of exposure to vehicular emissions including benzene) was essentially the same for the cases and referents.

## **9. Tobacco, Incense, Marijuana**

A number of smoke-related items were found to be statistically significant.

### **Cigarettes**

Smoking by staff at a day care, preschool, or school was associated with an elevated risk (odds ratio = 2.7). Parental smoking during the interval from birth to diagnosis also carried an elevated risk: father's smoking (OR=1.5; p=.03); any parent smoking (OR=1.5; p=.03); but not mother smoking (OR=1.2; p=.37). The dose-response relationship with regard to the number of cigarettes smoked per day was weak (OR=1.15 per 10 cigarettes), and it did not reach significance (lopsided p=.0931).

### **Cigars or pipe**

Smoking among fathers was related to case/referent status (OR=1.94), and even more strongly if it was in the interval from birth to diagnosis (OR=2.1; p=.045).

### **Marijuana**

Anyone else (other than parents) in the household smoking marijuana (3 months before birth to diagnosis) was significant (OR=2.44; lopsided p=.04). However, parental smoking of marijuana was not a risk factor.

A number of related items were not found to be risk factors. Neither incense burning, nor cigarette smoking by the case-children, nor marijuana smoking by the case-children were risk factors. However, the number of children old enough to smoke was small.

## **10. EMF**

We asked about exposure to thirteen appliances/items in the home. The only item of significance was the child's use of a black and white television (OR=1.5; lopsided p=.04).

## **11. Migration**

Neither the number of residences in which a child had lived, nor ever having moved was a risk factor.

## **12. Schooling in WCP and Maricopa county**

Attendance at schools located in WCP was not a significant risk factor. Attendance at schools located in proximity to contaminated wells (within 0.5, 1.0, and 2.0 miles) anywhere in Maricopa county also was not a risk factor.

### **13. Metal welding, dust, fumes**

Few persons were exposed, and the differences in exposures were not significant.

### **14. Sources of drinking water in the home**

The cases and referents did not differ according to the sources of drinking water at residences between birth and diagnosis: local water system (OR=.9); private well (OR=1.8); local system with a filter (OR=.7); bottled water (OR=1.1). None of these odds ratios was statistically different from 1.0.

### **15. Use of irrigation water**

The cases and referents did not differ according to the proportion that played in irrigation water, nor that ate fresh fruits or vegetables without washing or peeling them, nor that ate home-grown fruits or vegetables.

### **16. Plastic pipe at home**

Plastic plumbing pipe in the home was not a risk factor.

### **17. Swimming pool: home or public**

Neither swimming in pools at home nor use of public pools was a risk for leukemia.

### **18. Operation during pregnancy, C-section, perinatal complications**

None of the items assessed was a risk factor. For example, 14% of cases and referents were born by C-section. Low birth rate (under 2500 grams [5.5 lbs]) occurred in 4.8% of cases and 3.5% of referents. None of these differences was statistically significant.

### **19. Poisoning of the child; use of medications**

Poisonings were not a risk factor. The only medicine that was associated with an increased risk was use of non prescription vitamins (OR=1.6; p=.02). However, the use of prescribed vitamins was not a risk factor (OR=1.18; p=.52) and further analyses failed to show a dose-response effect.

### **20. Preconceptional exposure to herbicides**

Neither exposure to Agent Orange nor herbicides was a risk factor.

### **21. Child's use of illegal substances**

The child's use of so-called illegal substances (beer, liquor, stimulants, or marijuana) was not a risk factor.

### **22. Occupation and Industry of the parent (not specific for solvents or pesticides)**

After adjustment for multiple tests, the classification of parental job according to occupational title or industry was unrelated to status as a case or referent.

### **23. Consumption of specific food items**

There was a statistically significant difference in the child's consumption of several specific items: ham, bacon, or sausage (OR=2.1); hot dogs (OR=2.0); hamburgers

(OR=1.9); grapefruit or grapefruit juice (OR=1.8); charcoal broiled meats (OR=1.8); coffee (OR=3.0); and colas (OR=1.8). However, the cases were more likely to have consumed every food item we asked about. We interpret this as evidence of recall bias.

## 24. Home environmental sampling results

### Residential levels (measured)

In contrast to hypotheses that relied upon the collection of data via parental recall, this portion of the study utilized home measurements, albeit the samples were taken many years after the diagnosis date. Environmental samples were taken in 80 homes occupied by families since the reference (diagnosis) date. Only three such homes meeting the testing requirements were located in WCP. An EPA reference laboratory analyzed the samples of air, dust, and soil for many chemicals. We present the results here according to status as a case or referent, regardless of where the family lived in Maricopa county (because there were so few homes sampled in WCP).

Here, by “higher” we mean “statistically significantly higher.” The levels of a few chemicals were higher in the air at **case** homes than in referent homes; these chemicals were: 1,2,4-trimethylbenzene; benzene; ethylbenzene; hexane; methylene chloride; and n-pentane. Because the air samples were “grab/spot” samples reflecting the quality of the air only at the instant the sample was taken, there is little reliability in the air findings. Household dust and outdoor soil also were analyzed. The homes of the **referents** had higher measured levels of several chemicals in dust: Alpha-Chlordane; Chlorothalonil; Dibenz(a,h)anthracene. The homes of **cases** had higher levels of these chemicals in soil: Benz(a)anthracene; Benzo(b)fluoranthene; Chrysene. The levels of all these chemicals were very low, and none of the measured levels appeared to be of public health significance.

### Parent's Comments

The full report contains comments offered by the parents. The comments addressed many topics including their concern about the environment and personal and familial attributes.

## DISCUSSION AND CONCLUSION

The participation rate was less than we had anticipated, especially among cases from WCP, raising questions about biased ascertainment and participation of the cases. The method used to solicit information about past exposures (that is, parental recall on a questionnaire) also is a potential source of bias. Other sources of uncertainty include the imprecise manner of determining the sources of water and air pollution.

It is problematic to distinguish which of the significant results are real and which are due to the fact that we performed so many hypotheses tests, because by chance alone we would expect a few hypotheses tests to show statistical significance.

The use of residential addresses to measure exposure to sources of environmental contamination is a strength of the study, and provided a quasi-objective measurement of exposure.

Despite the limitations noted above, we conclude that the environmental factors we studied did not contribute significantly to the occurrence of leukemia cases in Maricopa

county or WCP. We found a statistical association with living in proximity to the gasoline Tank Farm, but the nature of the risk awaits further investigation. Smoking by the father, or either one or the other parent, was a weak, but significant, risk factor for child leukemia. Parental smoking has been noted as a risk factor in other studies of adult leukemia, but rarely has been studied or reported as a risk factor for childhood leukemia.

### **RECOMMENDATIONS**

1. The finding of the elevated risk associated with the gasoline Tank Farm warrants further evaluation of both air and water to confirm previous findings that significant levels of petroleum products are not present in current samples.
2. Parents should be warned of the risk to their children associated with parental cigarette and cigar smoking.

**CHILDHOOD LEUKEMIA STUDY IN MARICOPA COUNTY, 1965-1990**  
**SIMPLIFIED TABLE OF FINDINGS**

We have condensed and generalized the study's findings into the single table shown below. The reader should keep several points in mind here. An "association" is a statistical link that does not necessarily imply the factor caused leukemia; some of these associations can occur for other reasons, such as a tendency for case parents to recall events better than the referent parents (i.e., "recall bias"). The words "statistically significant" mean that the results were unlikely to have occurred by chance. Since this Table is a simplification of detailed analyses, the full text of the report should be reviewed for explanation concerning specific items.

**O.R. is the Odds Ratio of Exposure, Cases to Referents**

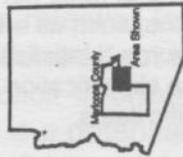
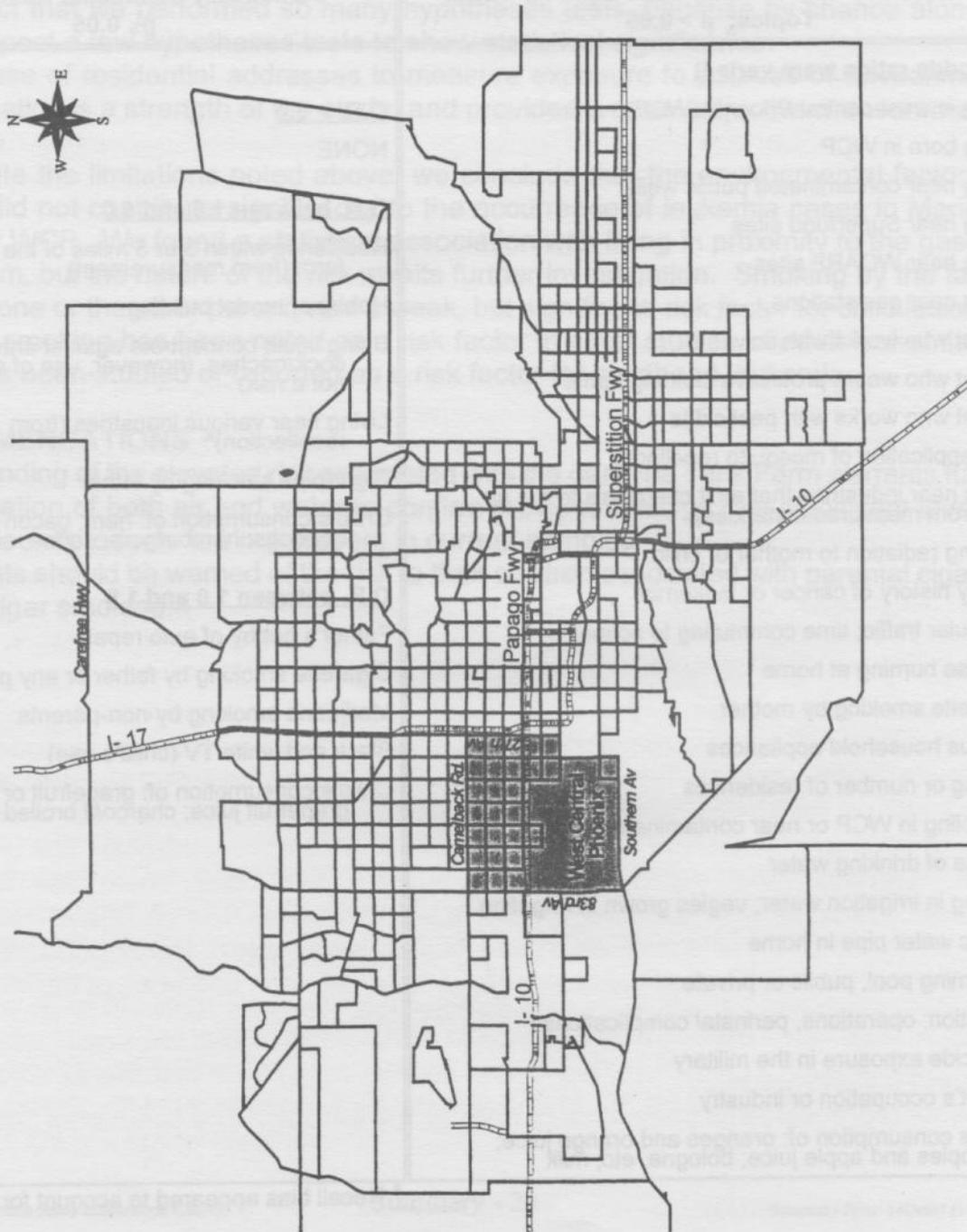
<b>No Statistical Significance was Found for These Topics: <math>p &gt; 0.05</math></b>	<b>Statistically Significant Associations <math>p \leq 0.05</math></b>
<p><b><u>(the odds ratios were varied)</u></b></p> <p>Living in west central Phoenix (WCP)</p> <p>Being born in WCP</p> <p>Living near contaminated public wells</p> <p>Living near Superfund sites</p> <p>Living near WQARF sites</p> <p>Living near gas stations</p> <p>Parent who works with solvents</p> <p>Parent who wears protective clothing home</p> <p>Parent who works with pesticides</p> <p>Skin application of mosquito repellants</p> <p>Living near industries that emit chemicals to the air (from measured distances)</p> <p>Ionizing radiation to mother or child</p> <p>Family history of cancer or leukemia</p> <p>Vehicular traffic; time commuting to school</p> <p>Incense burning at home</p> <p>Cigarette smoking by mother</p> <p>Various household appliances</p> <p>Moving or number of residences</p> <p>Schooling in WCP or near contaminated wells</p> <p>Source of drinking water</p> <p>Playing in irrigation water; vegies grown in irrigation</p> <p>Plastic water pipe in home</p> <p>Swimming pool, public or private</p> <p>C-section; operations, perinatal complications</p> <p>Herbicide exposure in the military</p> <p>Parent's occupation or industry</p> <p>Child's consumption of: oranges and orange juice; apples and apple juice; bologna, etc; milk</p>	<p><b><u>O.R. &gt; 5.0</u></b></p> <p>NONE</p> <p><b><u>O.R. between 1.8 and 5.0</u></b></p> <p>Residence within 3 or 5 miles of the gasoline tank farm (from measurement)</p> <p>Hobby of model building</p> <p>Using liquid concentrate against ants and cockroaches. (however, use of sprays was not a risk)</p> <p>Living near various industries (from recollection)<sup>&amp;</sup></p> <p>Cigar/pipe smoking by father</p> <p>Child's consumption of: ham, bacon or sausage; hot dogs; hamburgers; coffee; colas<sup>&amp;</sup></p> <p><b><u>O.R. between 1.0 and 1.8</u></b></p> <p>Father's hobby of auto repair</p> <p>Cigarette smoking by father or any parent</p> <p>Marijuana smoking by non-parents</p> <p>Black and white TV (child's use)</p> <p>Child's consumption of: grapefruit or grapefruit juice; charcoal broiled meats<sup>&amp;</sup></p>

<sup>&</sup> Recall bias appeared to account for these findings.

FIGURE 1

# Location of West Central Phoenix

Maricopa County, Arizona



State of Arizona



0 2 4 6 8 Miles

Map drawn 5/9/96

## LIST OF ATTACHED MAPS

1. Contaminated wells
2. Contaminated wells, eastside
3. Contaminated wells, westside
4. Tank Farm
5. Airborne VOC sources and gas stations
6. Superfund and WQARF sites
7. Traffic density
8. Cases and referents: cumulative residential location (with offset )

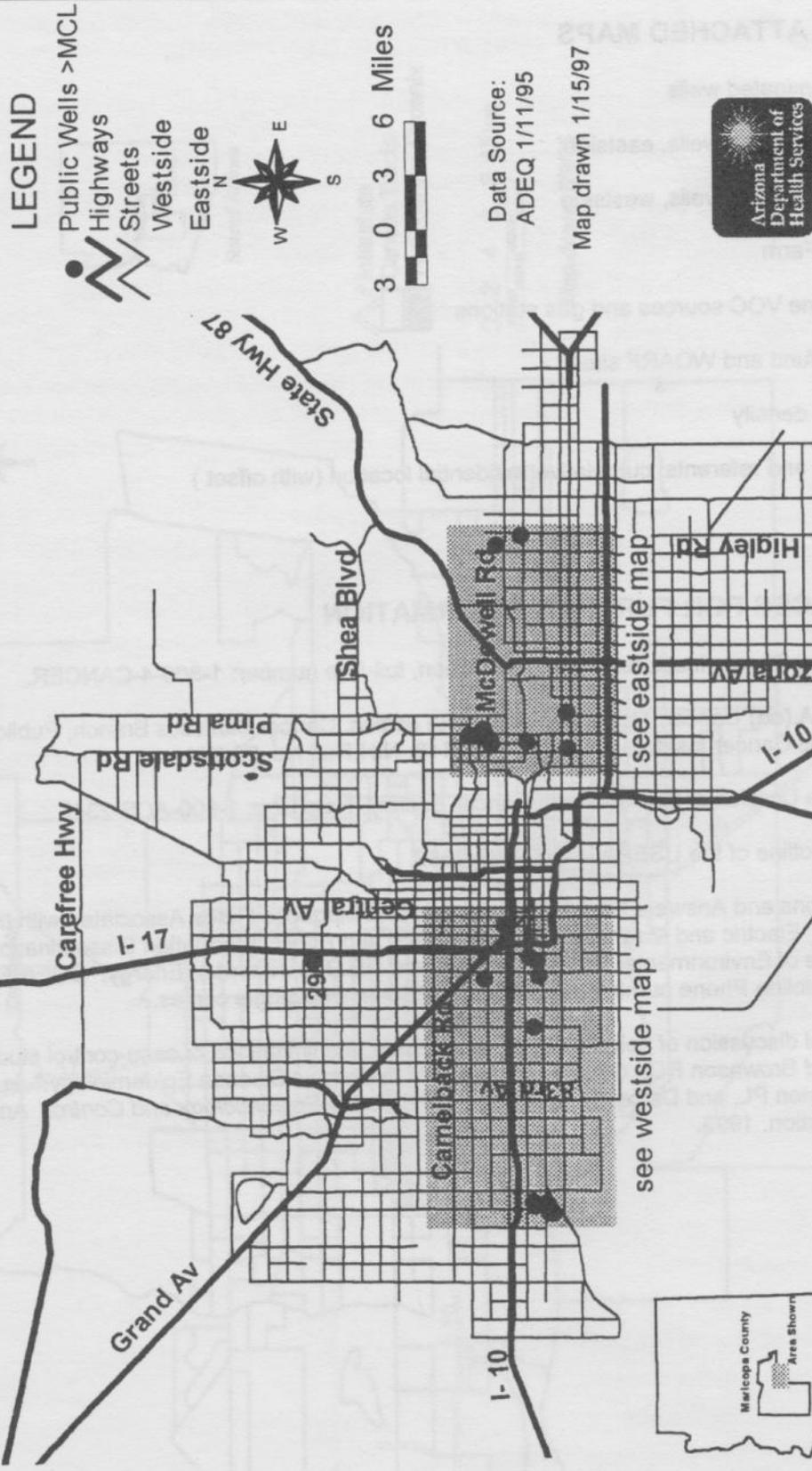
## RESOURCES FOR FURTHER INFORMATION

1. National Cancer Institute, public information, toll-free number: 1-800-4-CANCER.
2. Harris A.(ed) *Cancer: Rates and Risks, 4th edition*. Cancer Statistics Branch, Public Health Service, National Cancer Institute. 1996. pp 124; 148. NIH Pub No. 96-691.
3. Arizona Division of the American Cancer Society, Help Line: 1-800-ACS-2345
4. EMF Hotline of the USEPA: 1-800-363-2383.
5. Questions and Answers About EMF: Electric and Magnetic Fields Associated with the Use of Electric Power. Electric and Magnetic Fields Research and Public Information Dissemination Program, National Institute of Environmental Health Sciences and US Department of Energy. DOE/EE-0040. January 1995. EMF Infoline Phone number is 1-800-363-2383 for free single copies.
6. General discussion of epidemiologic approaches and limitations of case-control studies: Savitz DA, Harris RP, and Brownson RC. Chapter 2: "Methods in Chronic Disease Epidemiology." in Brownson RC, Remington PL, and Davis JR (eds). *Chronic Disease Epidemiology and Control*. American Public Health Association. 1993.

MAP #1

# PHOENIX METRO AREA

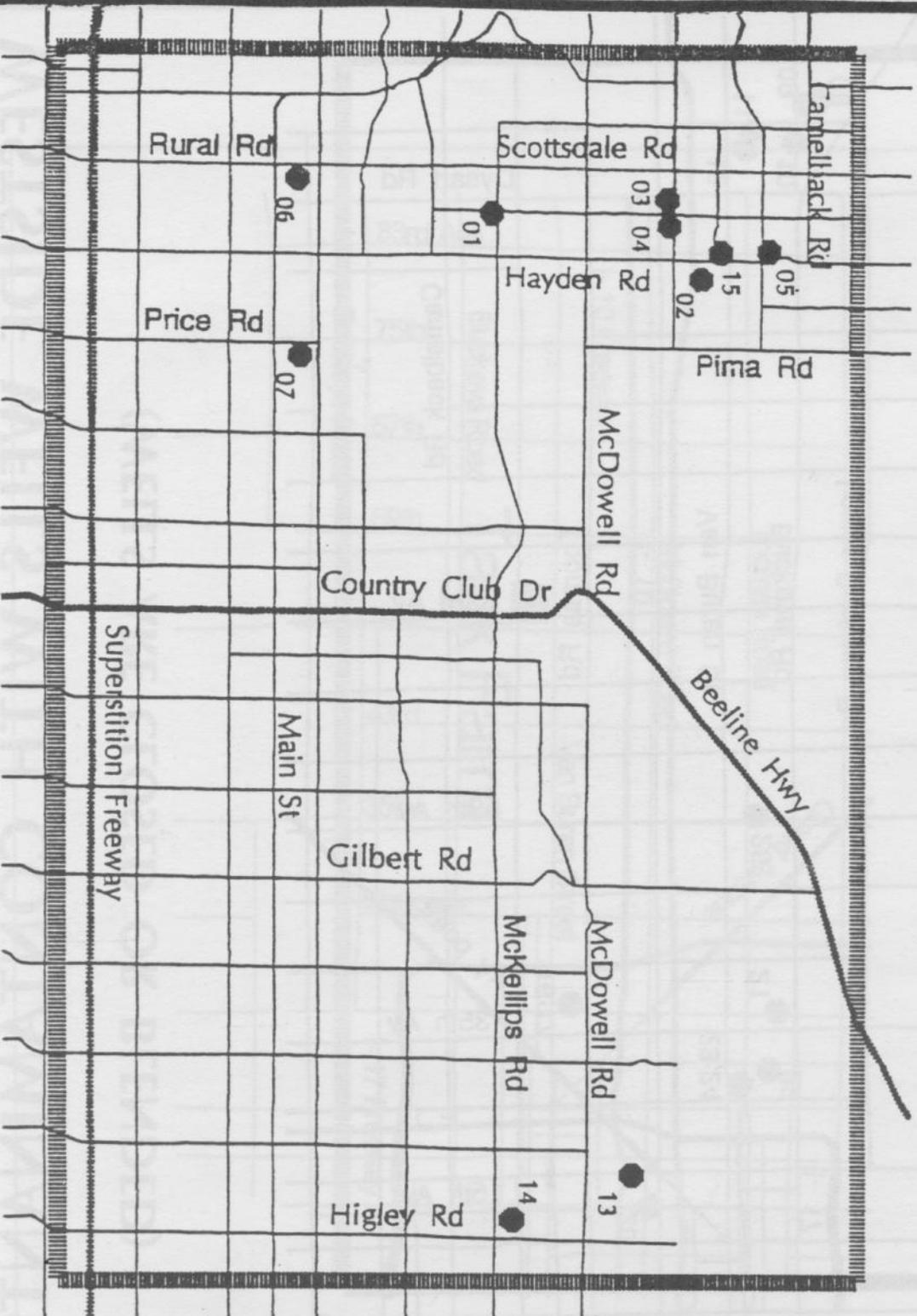
## PUBLIC WELLS FORMERLY EXCEEDING MAXIMUM CONTAMINANT LEVEL



Note: Wells exceeding MCL's are now regulated to insure that they are not used for drinking water.

MAP # 2  
**EASTSIDE WELLS WITH CONTAMINANTS OVER MCL**

(WELLS ARE CLOSED OR BLENDED)



**LEGEND**

-  Eastside Map
-  Wells over MCL
-  Highways
-  Streets



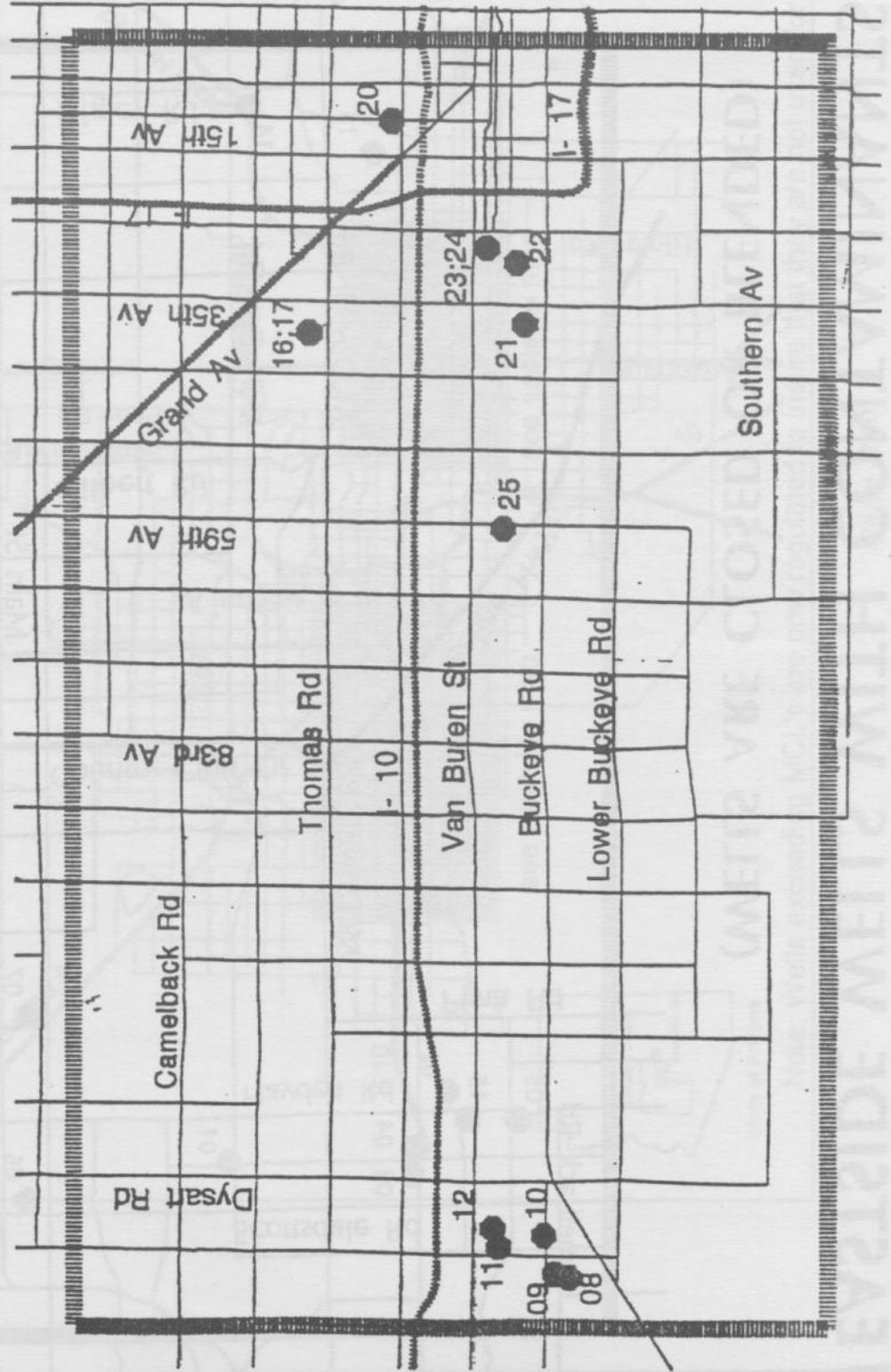
Data source:  
 ADEQ 1/11/95

Map Drawn 4/9/96

MAP #3

# WESTSIDE WELLS WITH CONTAMINANTS OVER MCL

(WELLS ARE CLOSED OR BLENDED)



## LEGEND

- Westside Map
- Wells over MCL
- Highways
- Streets

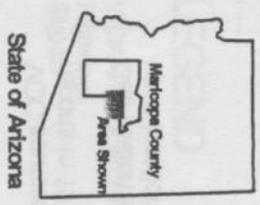
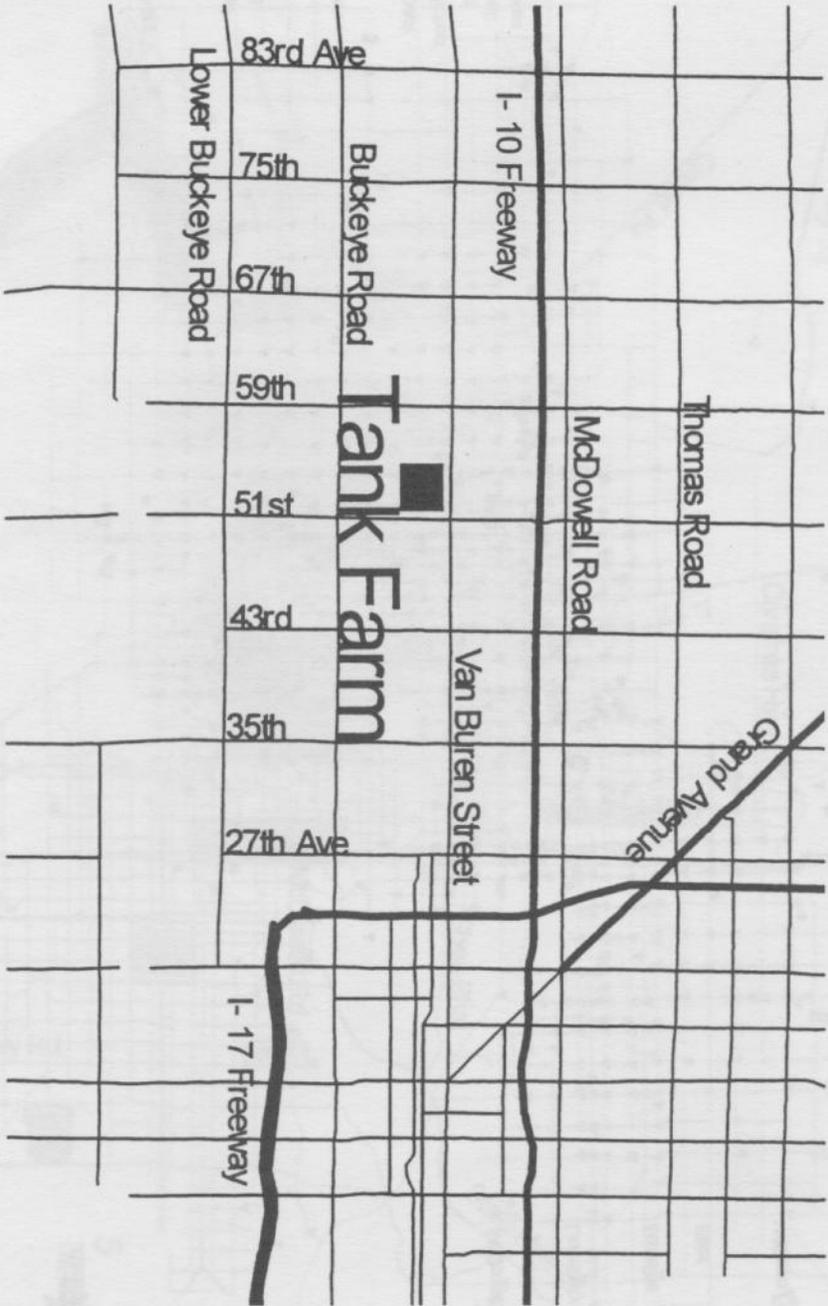


0 1 Miles

Data source:  
ADEQ 1/11/95

Map Drawn 4/9/96

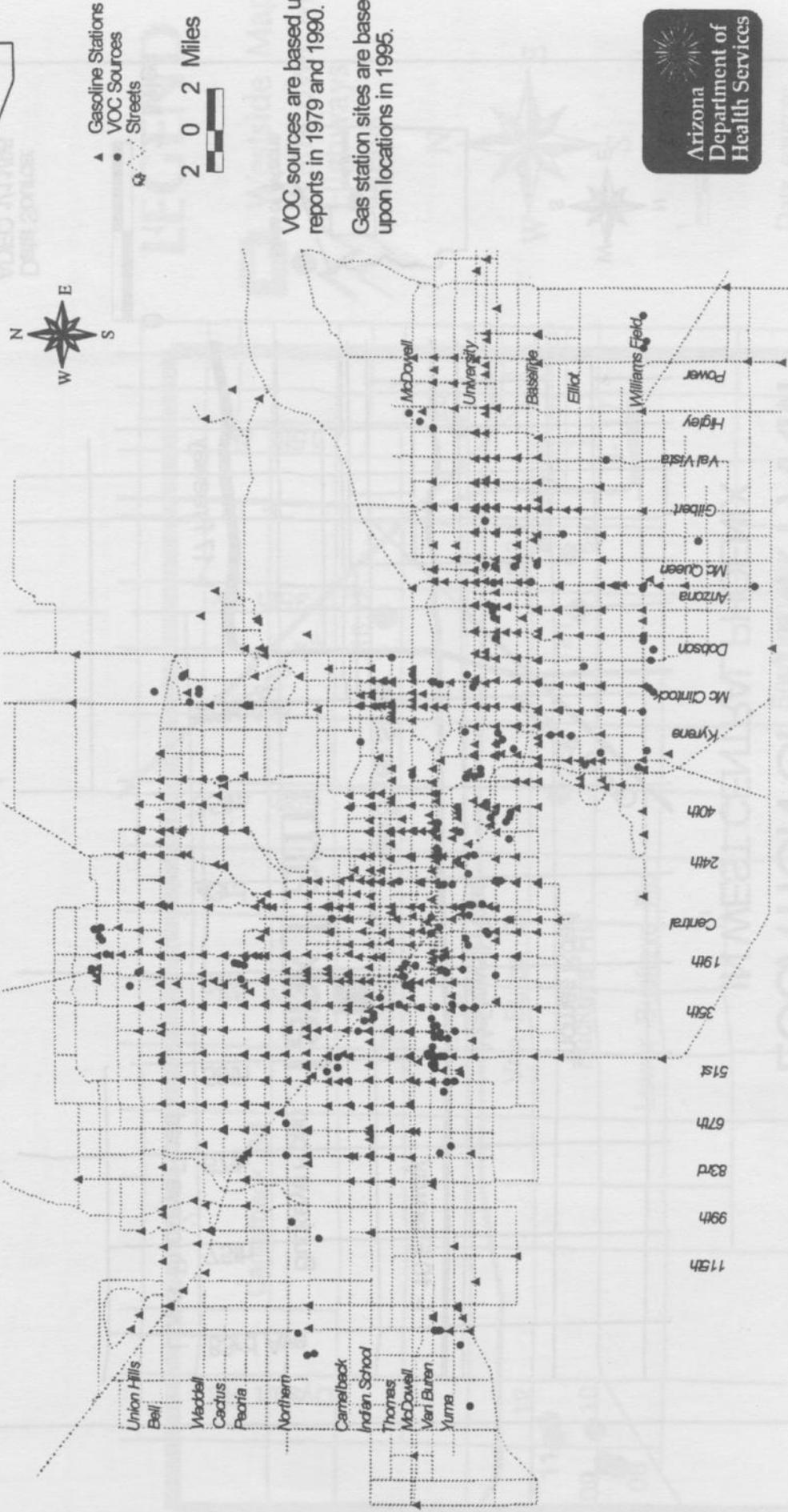
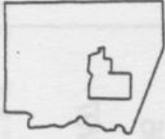
# LOCATION OF TANK FARM IN WEST CENTRAL PHOENIX



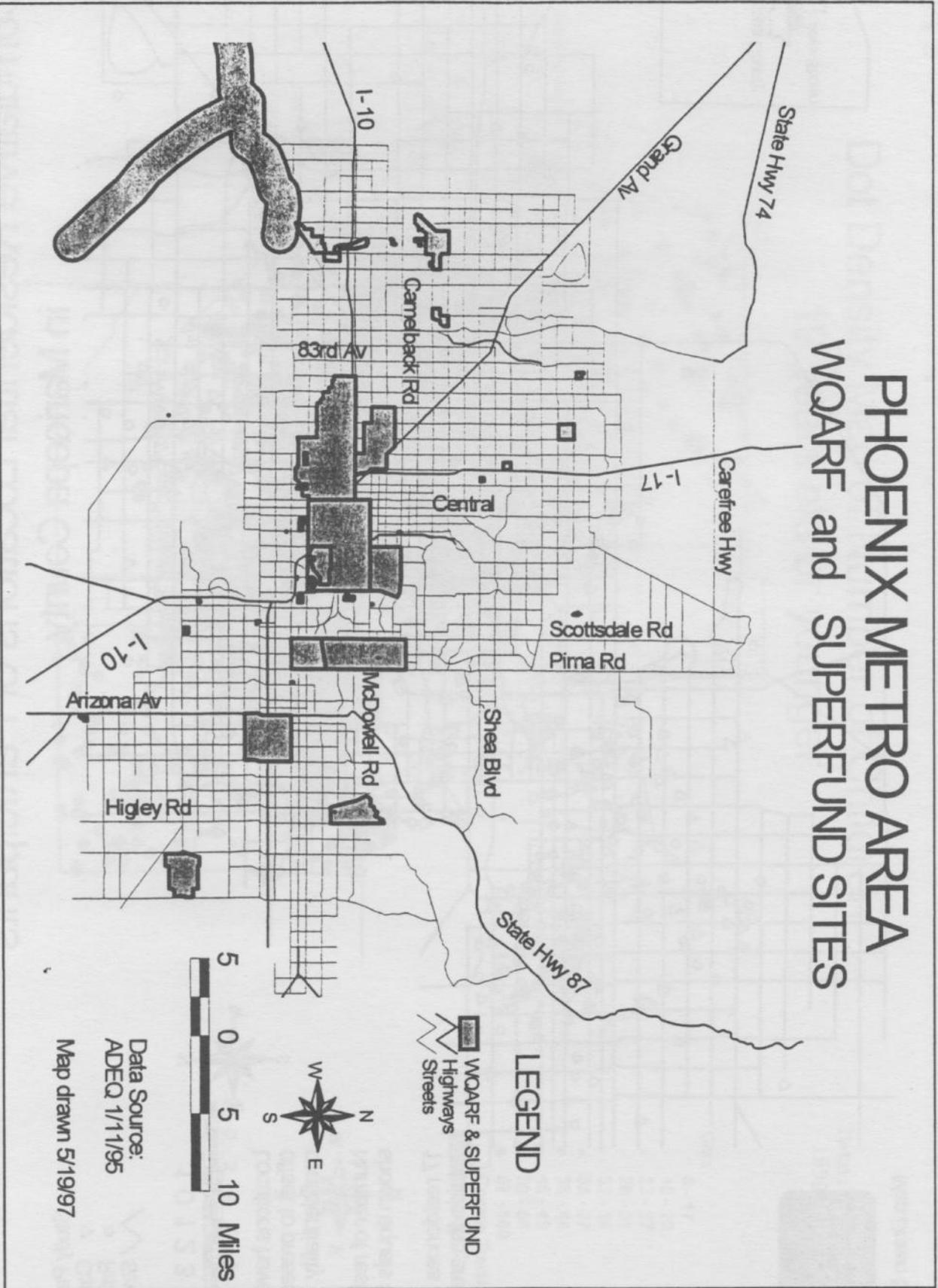
Data Source:  
ADEQ 1/11/95  
Map drawn 4/4/97

# Sources of Stationary Airborne Organic Chemical Emissions

## Maricopa County, Arizona

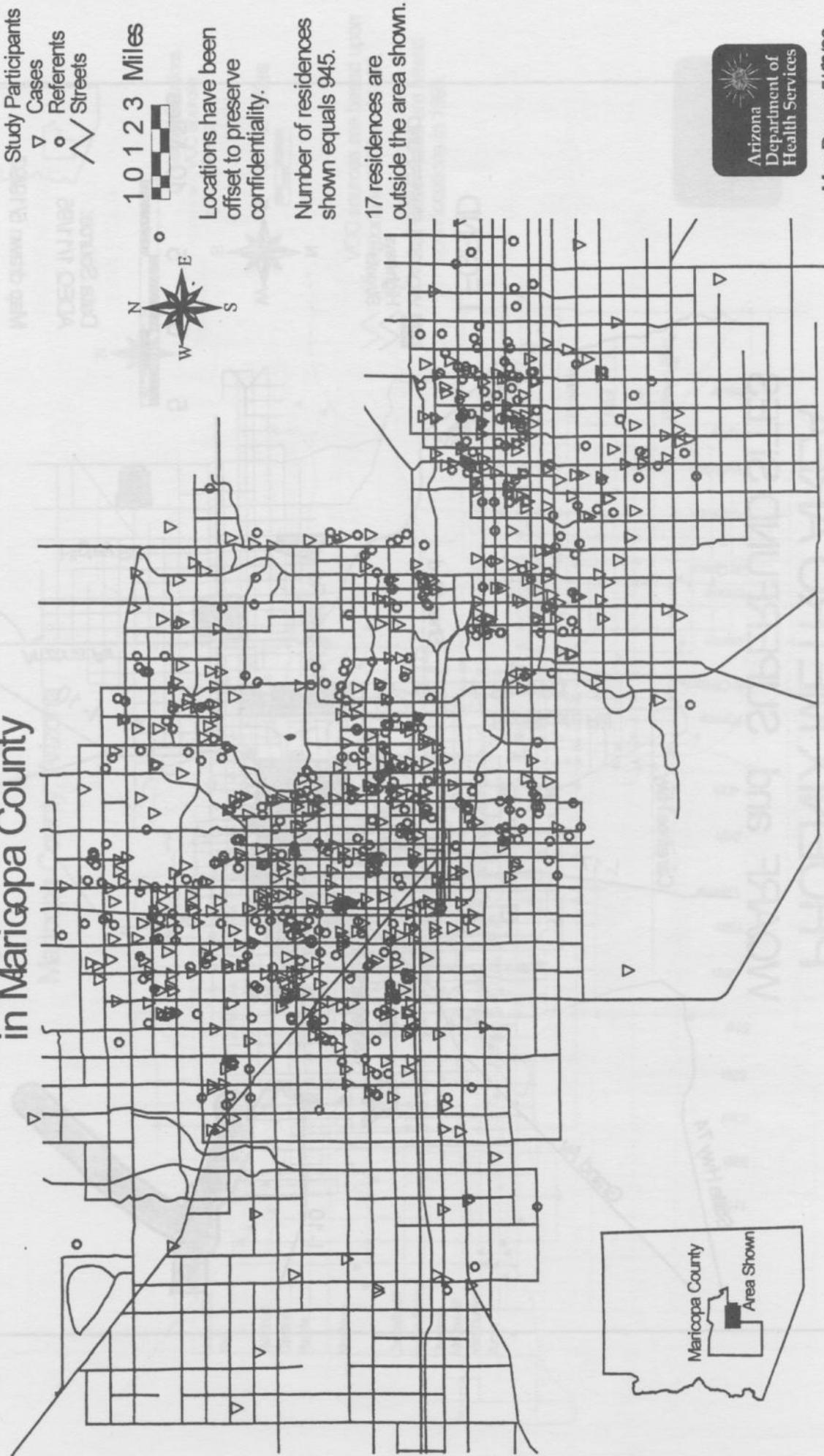


# PHOENIX METRO AREA WOARF and SUPERFUND SITES



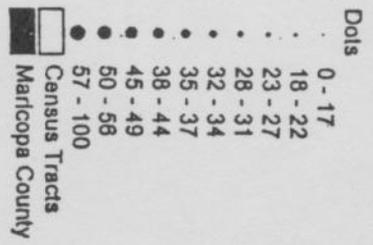
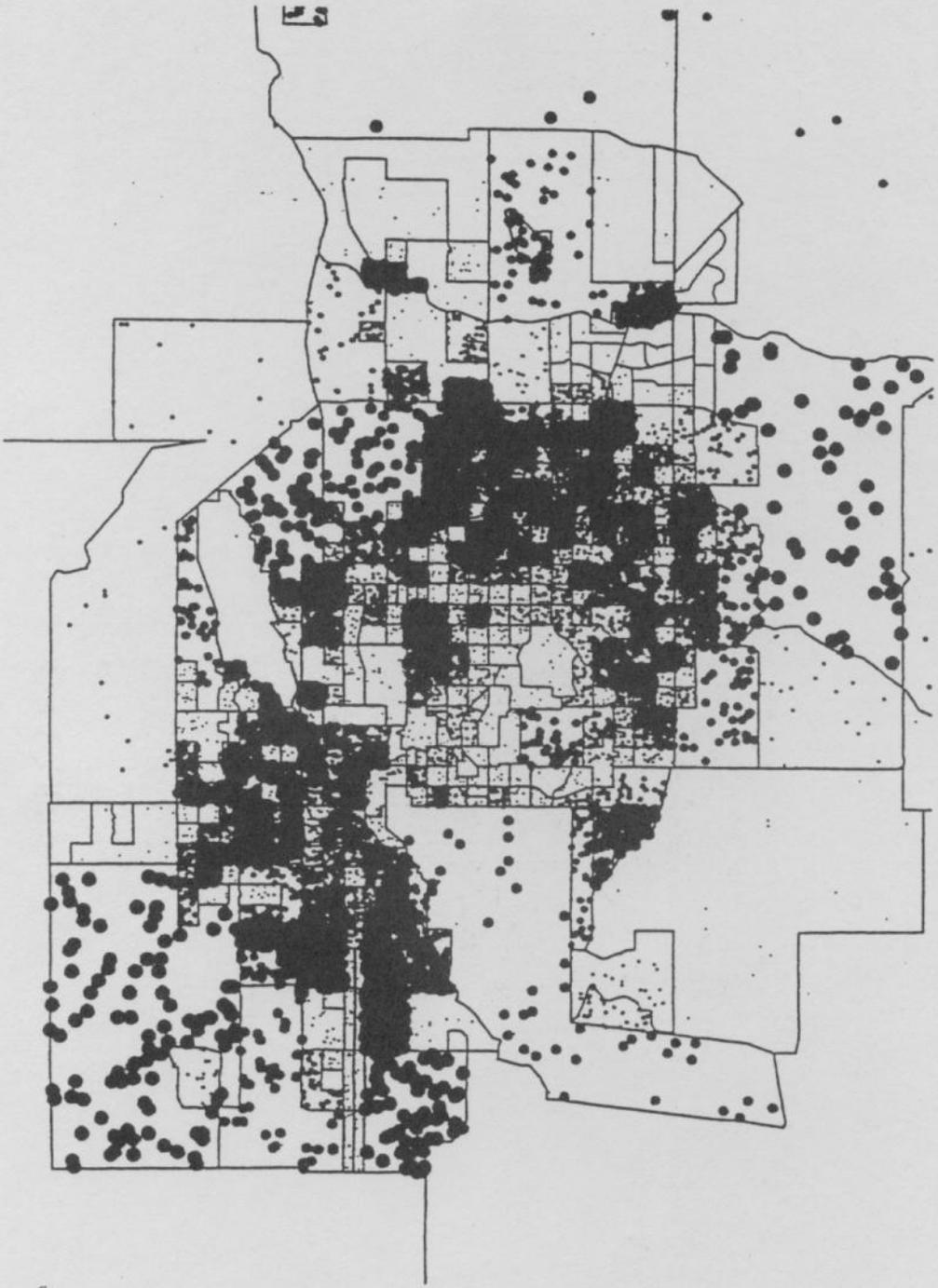
MAP # 7

# Cumulative Residential Locations of Participants in Maricopa County

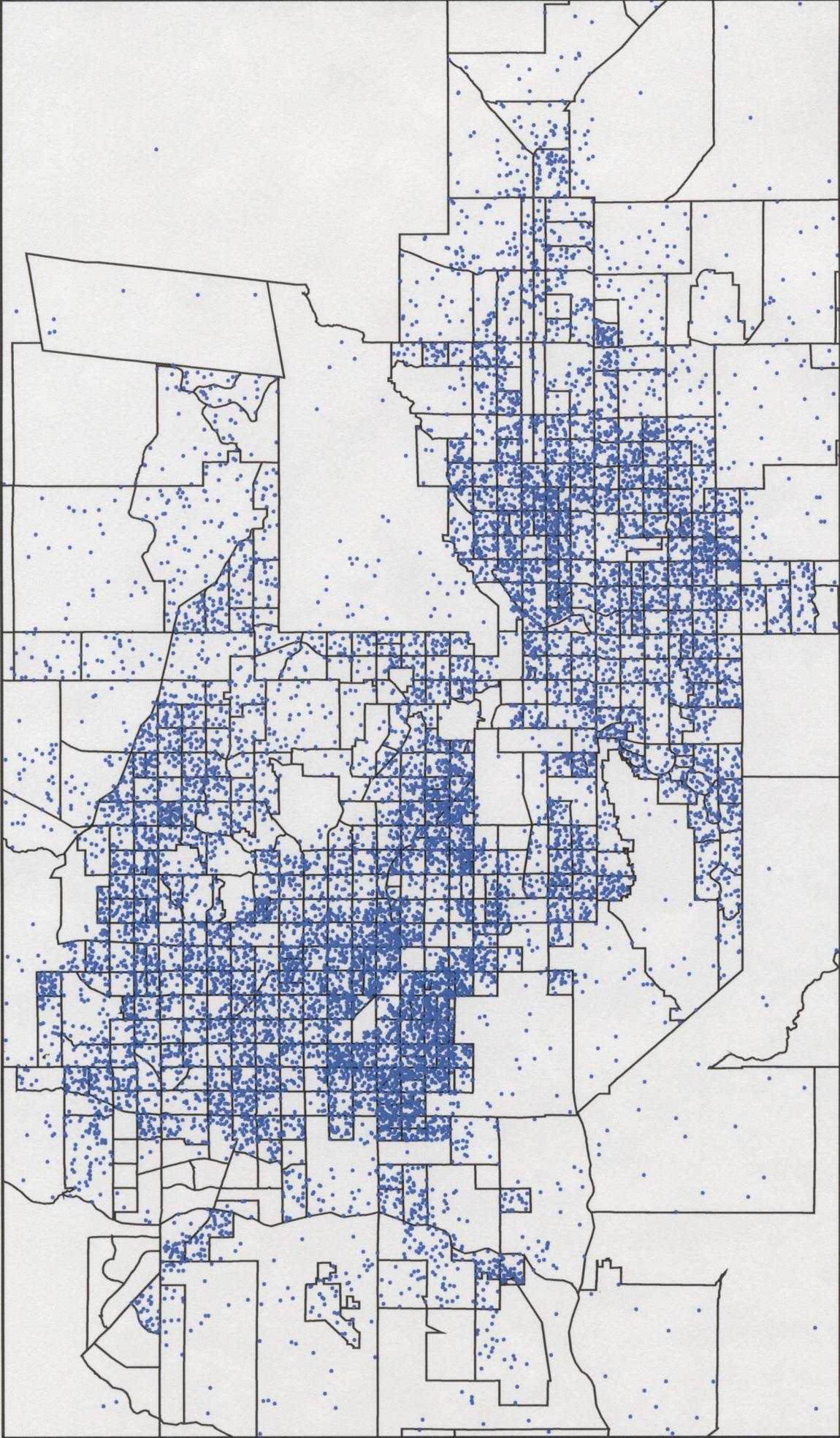


# Dot Density Map of Number of Children 19 years old or younger

Data:  
1990 Census



# Dot Density Map of Number of Children 14 Years Old or Younger



2000 Census Tracts

1 Dot = 50 Children  
14 Years Old or Younger



Source Data: 2000 Census

