ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

Analysis for Pesticide Residues in Soils
West Central Phoenix 1992

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West Central Phoenix

Prepared By

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The Arizona Department of Environmental Quality shall preserve, protect and enhance the environment and public health, and shall be a leader in the development of public policy to maintain and improve the quality of Arizona's air, land and water resources.

EDWARD Z. FOX, DIRECTOR

FIFE SYMINGTON, GOVERNOR

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Acknowledgments

Many agencies and individuals contributed to and assisted with this study. The study would not have been made possible without their cooperation:

Arizona Department of Health Services

Arizona Department of Agriculture

Arizona Structural Pest Control Commission

City of Phoenix

Mothers of Maryvale

US Environmental Protection Agency

US Soil Conservation Service

University of Arizona

Especial thanks are also warranted for the efforts of the following individuals:

Melody Baker, Mothers of Maryvale
Shirley Marotta, Friends for Environmental Safety
Winchester Chromec, ADHS

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Executive Summary

A relatively high number of deaths due to childhood leukemia were noted by residents of west central Phoenix in 1982. The concerns culminated when a 1990 incidence study prepared by the Arizona Department of Health Services confirmed a significant elevation of leukemia in west central Phoenix compared to Maricopa County and the United States.

Investigations of water supply, air quality, and radiation levels in west central Phoenix indicated that contaminants did not exceed standards or were no higher than the rest of the Phoenix metropolitan area. One concern that was not addressed was the nature of residuals of pesticides in the soil. The urbanized part of west central Phoenix was previously in agricultural use characterized by frequent application of pesticides. Some pesticides are very persistent, and their residues could carry over into developing residential areas. Besides agricultural pesticides, others are used around structures, parks and schools for termites and other pests. This study was proposed with the intent of characterizing residuals of pesticides in soils with regard to their occurrence and source.

The study was conducted in two phases. Phase I (Summary Table, Page 3) included taking soil samples of agricultural areas in west central Phoenix. Phase II (Summary Tables, Pages 4-5) involved taking soil samples in the residential and public areas of west central Phoenix.

The results of the Phase I sampling indicated the consistent presence of DDT, DDD and DDE and toxaphene at the agricultural sites, likely due to agricultural practices. None of the samples contained a concentration of total DDT compounds higher than the Health Based Guidance Level (HBGL) of 2.0 mg/kg. One of the samples had a concentration of toxaphene higher than the HBGL of 0.6 mg/kg. Arsenic was also detected but at a concentration considered naturally occurring for the area. There is little doubt that DDT, DDD and DDE and toxaphene residuals are associated with agricultural activities.

The results from the Phase II sampling indicated frequent detections of DDT, DDD and DDE, arsenic, chlordane and dieldrin at the residential and public sites. The Phase II samples revealed arsenic concentrations which were within the range of concentration naturally occurring in soils. It is unlikely its presence is the result of structural pest control or agricultural practices.

Chlordane and dieldrin residues were highly associated with residential structural samples (i.e. around foundations). Residuals of DDT, DDD and DDE were found in nearly all samples, but demonstrated higher concentrations in samples taken near structures.

All three compounds were detected at levels that occasionally exceeded the HBGLs. It is likely that the higher residuals of these compounds were supplemented by residential structural pest control applications. DDT, DDD and DDE found elsewhere in the lawn, garden, and public areas are likely a carry-over from agricultural activities with some supplemental structural use.

Toxaphene appeared sporadically in the Phase II samples while it was consistently detected in the Phase I samples. The compound is probably a carry-over from agricultural activities except where it occurs in higher concentrations at some residential sites where it may have been used for site specific urban pest control.

The Phase II data was compared with levels of pesticides detected in other U.S. cities. The comparison revealed that the concentrations of compounds found in the residential areas of west central Phoenix were not significantly above or below the levels in other U.S. cities.

As a result of this study, it is recommended that the Arizona Department of Health Services include an analysis of soils for all pesticides detected in the Phase II portion of this study, in all future case-control studies. It is also recommended that future research be conducted in the area to 1) further characterize DDT and toxaphene residuals in the Phoenix area to support a human health and environmental risk assessment, 2) expand HBGL's to include inhalation risks for pesticides and 3) re-evaluate Health Based Guidance Levels for significance of risk associated with the levels of contamination found by this study.

Summary of Detections at Agricultural Sites

Chemical	# of Sites	# of Samples	# with Detection	#> = HBGL's	Range of Values (ppm)
Arsenic	4	13	13	0	3.0 - 32
DDD + DDE + DDT	4	13	13	0	ND - 1.31
Dieldrin	4	13	0	0	ND
Endosulfan I	4	13	0	0	ND
Lindane	4	13	0	0	ND
Toxaphene	4	13	12	0	ND - 1.04

Summary of Detections at Residential Sites

Chemical	# of Samples	# with Detections					# > = HBGL's					Range of Values (ppm)
		L	S	G	P_1	P_2	L	S	G	P_1	P_2	
Aldrin	26	0	1	0	0	0	0	1	0	0	0	ND - 9.7
Arsenic	26	9	9	3	3	2	0	0	0	0	0	11.0 - 29.0
Chroldane	26	7	8	2	3	2	5	7	2	2	2	ND - 290.0
DDD + DDE + DDT	26	7	7	3	1	1	1	4	0	0	0	ND - 12.0
Diazinon	26	0	1	0	0	0	0	0	0	0	0	ND - 0.29
Dieldrin	26	7	7	2	0	2	7	7	2	2	1	ND - 30.0
Endosulfan I	26	0	0	0	0	1	0	0	0	0	0	ND - 0.70
Endrin	26	1	1	0	0	0	0	0	0	0	0	ND - 1.2
Heptachlor	26	0	1	0	0	0	0	1	0	0	0	ND - 4.2
Heptachlor Epoxide	26	2	1	0	0	0	1	1	0	0	0	ND - 0.8
Toxaphene	26	1	1	0	0	0	1	1	0	0	0	ND - 1.0
Ziram	26	0	0	0	0	1	HBGL Not Available					ND - 0.25
2,4-D	26	1	1	0	0	0	0	0	0	0	0	ND - 0.13

Location:

L = lawn	9 samples
S = foundation	9 samples
G = garden	3 samples
P_1 = play area (0-6")	3 samples
P_2 = play area (6-12")	2 samples

Summary of Detections at Public Sites

Chemical	# of Samples	# with Detection					# > = HBGL's					Range of Values (ppm)
		F_1	F_2	P_1	P_2	I *	F_1	F_2	P_1	P_2	I *	
Aldrin	24	0	0	0	0	0	0	0	0	0	0	ND
Arsenic	24	8	8	5	2	1	0	0	0	0	0	5.4 - 35.0
Chlordane	24	0	0	1	1	0	0	0	0	0	0	ND - 0.24
DDD + DDE + DDT	24	5	6	0	1	1	0	0	0	0	0	ND - 1.1
Diazinon	24	0	0	0	0	0	0	0	0	0	0	ND
Dieldrin	24	0	0	0	0	0	0	0	0	0	0	ND
Endosulfan I	24	0	0	0	0	0	0	0	0	0	0	ND
Endrin	24	0	0	0	0	0	0	0	0	0	0	ND
Heptachlor	24	0	0	0	0	0	0	0	0	0	0	ND
Heptachlor Epoxide	24	0	0	0	0	0	0	0	0	0	0	ND
Toxaphene	24	1	2	0	1	0	1	1	0	0	0	ND - 1.0
Ziram	24	0	1	0	0	0	HBGL Not Available					ND - 0.35
2,4-D	24	0	1	0	0	0	0	0	0	0	0	ND - 0.05

Location:

F_1 = ball field (0-6")	8 samples
F_2 = ball field (6-12")	8 samples
P_1 = play area (0-6")	5 samples
P_2 = play area (6-12")	2 samples
I = irrigation ditch	1 sample

I. Objective of the Study

This study was developed to identify and quantify agricultural, structural, and home use pesticide residues that may be found in the 0" to 6" surface soil in west central Phoenix. The 0" to 6" surface soil offers the greatest potential for human exposure by skin contact, ingestion, or inhalation.

The results of this study will also serve as an aid for future case control studies for the Arizona Department of Health Services (ADHS), as supportive documentation for the Arizona Department of Environmental Quality (ADEQ) remedial action programs, for interagency efforts to mitigate toxic pollution in the Salt and Middle Gila watersheds, and for assessing nonpoint source water pollution in the lower Salt River watershed.

II. Need for the Study

This study was conceived in response to concerns on the part of residents of west central Phoenix. The following discussion summarizes these concerns and reviews results of studies performed which investigated various aspects of the quality of the environment in the locale.

A. Cancer Incidence and General Health Concerns

A relatively high number of deaths due to childhood leukemia was noted by residents of west central Phoenix in 1982. The Arizona Department of Health Services (ADHS) conducted a leukemia mortality study of school age children in 1982. The study confirmed a higher than average number of leukemia-related deaths in that area.

Media attention in 1987 reactivated public concern about a childhood leukemia cluster in west central Phoenix. Residents in the area were concerned about a possible connection with chemical contaminants in the air, water, and soil.

A mortality study prepared by ADHS in 1988 again confirmed the observations of an elevated leukemia rate. An incidence study of childhood cancer in Maricopa County, which followed the mortality study, was also prepared by ADHS.

The incidence study investigated all reported childhood cancers in Maricopa County for children ages 0 - 19, and between the years 1965 - 1986. In its final report of April 1990, ADHS found that the incidence of childhood leukemia in west central Phoenix was significantly elevated above expected Maricopa County and United States rates in the overall time period (49 vs. 29 cases), and in the most recent time period between 1982 - 1986 (18 vs. 9.4 cases).

The study recommended an investigation focusing on establishing exposure to potential risk factors in Maricopa County with particular emphasis on those that might be present in west central Phoenix.

ADHS is currently planning to conduct case-control studies in the west central Phoenix area. These studies will investigate circumstances surrounding specific cases of leukemia. Factors such as air quality, indoor air, electric and magnetic radiation (inside and outside the home), and occupational and residential exposures to environmental factors will be considered.

B. Previous Environmental Studies

Investigations of water supply, air quality, and radiation have been performed in west central Phoenix. The studies were conducted to identify contaminant sources which may contribute to health concerns, and particularly to leukemia. In general, the studies documented that contaminants did not exceed standards or were no higher than the rest of the Phoenix metropolitan area, or that the health effects of contaminants detected were unknown.

1. Water

The City of Phoenix water supply currently consists of approximately 90 percent surface water and 10 percent groundwater. Potable water in Maricopa County is required to be tested for particular contaminants on a regular basis. The City of Phoenix monitors most wells in use at least quarterly; some are monitored more frequently.

Two wells (numbers 70 and 71) in west central Phoenix were taken out of service in 1982 for TCE contamination. According to the City, the water from the two wells was blended with nearby City water sources prior to discovery of the contamination. This blending would have resulted in lower TCE concentrations in the distribution system than was found in the wells. The City estimated that six square miles in west central Phoenix had the highest probability of receiving water from the two wells. That area is bounded by McDowell Road and Indian School Road on the south and north and 27th and 51st Avenue on the east and west. When ADHS evaluated the incidence of leukemia in this area, no relationship was found between the geographical area served by these wells and the incidence of leukemia.

Additional wells were also taken out of service in west central Phoenix. They were well 151 for TCE and nitrates in 1989 and well 152 for nitrates in 1988, well 68 for total dissolved solids in 1986, well 100 for EDB in 1984, well 224 for nitrates in 1982, wells 156 and 157 for nitrates in 1989 and well 240 for nitrates in 1991.

The service areas for these latter wells cannot be determined given the nature of the distribution of the water system, pipe sizes, and nearby water sources. Similar to wells 70 and 71, the water was blended with other City water sources prior to discovery of the groundwater contamination. As the City of Phoenix points out, elevated nitrate and total dissolved solids concentrations are reflective of regional groundwater quality problems, and are not considered to be cancer-causing and do not pose significant health risks if consumed by the general population.

2. Air

Surveys in the Valley were conducted in 1979 and 1984 for various volatile organic compounds (VOCs) including tetrachloroethylene, TCE, and benzene. The monitoring sites for the studies were the capitol area for the 1979 study; and 39th Avenue and Earl, the capitol area, Scottsdale and central Phoenix for the 1984 study. These surveys found levels of air pollutants comparable to those in other U.S. urban areas, and the levels were no higher than in other valley locations having comparable traffic.

A comprehensive study of VOCs in metropolitan Phoenix was prepared in 1987-88 by ADEQ. The monitoring sites included 39th Avenue and Earl, central Phoenix and 13 portable sites throughout the Phoenix area. The study showed that the average pollutant levels during periods of air stagnation were highest in west central Phoenix and central Phoenix. ADEQ found that on days when air pollutants were at their highest levels, there were no short-term health risks in Maricopa County and an insignificant long-term risk estimated at 1.5 excess cancer cases per year in metropolitan Phoenix (population approximately 2,000,000).

3. Radiation

The Arizona Radiation Regulatory Agency surveyed the west central Phoenix area for radiation contamination. One study included evaluating records of 16 radiation licensees and former licensees dating back to 1977. Radiation monitoring studies included a grid arrangement of 204 survey points throughout west central Phoenix. Airborne radiation was monitored at the Tank Farm, Maryvale Samaritan Hospital and St. Vincent de Paul School. Ambient gamma radiation was monitored at 25 sites in west central Phoenix. Classrooms in 32 Maryvale schools were monitored for radiation levels. The survey results indicated readings of normal levels of gamma radiation and radiation from radon gas in west central Phoenix.

4. Hazardous Waste Contamination

The ADEQ has identified 15 facilities as having on-site contamination of hazardous wastes in violation of the Resource Conservation Recovery Act. Eight of the facilities generated more than 100 kilograms of hazardous waste materials per month.

All of these facilities were inspected by ADEQ. Letters of warning were issued to 12 facilities. Laboratory analysis is pending from samples taken at two facilities. One site was recently inspected (November 1990). Of all the facilities, two had violations which have been resolved. The remaining facilities have pending cases. The significance of the contamination from these facilities with regard to human health is unknown.

Two sites in Phoenix have been designated by ADEQ to receive funding from the Arizona Water Quality Assurance Revolving Fund (WQARF). The first WQARF site is bounded by Camelback Road to the north, I-17 to the east, McDowell Road to the south and 83rd Avenue to the west. This site is known to have TCE contamination in the groundwater. Groundwater contamination in this area exists in three plumes. Interim findings indicate that the sources of the original contamination were industrial septic tanks and seepage pits which were used in the late 1950s to the late 1960s. At this time, ADEQ is negotiating for privately funded cleanups.

The second WQARF site is bounded by McDowell Road to the north, 7th Avenue to the east, the Salt River to the south and 75th Avenue/Roosevelt Canal to the west.

Numerous domestic, industrial and irrigation wells were contaminated with organic substances including benzene, PCE, TCE and 1, 1-DCE. Investigations are continuing to determine the source(s) of groundwater contamination. Several facilities in the area are conducting voluntary remedial activities.

5. Electric and Magnetic Fields

There have been no formal studies of electric and magnetic fields in west central Phoenix by Salt River Project (SRP). The utility has made readings for individual requests though no large study has been done. The ADHS will investigate electric and magnetic fields (such as home wiring) in their case control studies.

C. Need for the Project

A problem with most of the above environmental studies is the transient nature of the pollutant being studied. Results of such studies will only represent the conditions that existed at the time of monitoring. These results can only be extrapolated into the past to the extent that conditions in the past were similar to those at the time of monitoring.

For this reason, it is difficult to accurately characterize pollution events that occurred in the past. If particular human or environmental health problems were related to specific events, it is nearly impossible to link the two when evidence of the emission or discharge no longer exists.

Soil contamination, however, is not as transient or episodic as other pollution incidents. Depending on the susceptibility of a pollutant to environmental degradation and the extent to which a soil is disturbed by subsequent activity (i.e. development), it is possible to detect chemical residues in soil that reflect past contamination. This fact makes it possible to assess the extent to which past uses of pesticides have influenced present soil residues.

One concern that was not addressed in previous studies was the nature of residuals of pesticides in the soil which may have resulted from past agricultural, structural and home uses.

West central Phoenix has experienced significant population growth during the last 20 to 30 years. Parts of the area nearest the city center were developed into industrial-related land uses. Most of the area was in active agriculture prior to residential and commercial development. The type of agriculture present was characterized by frequent use of pesticides, including many varieties of insecticides and herbicides.

Some of these pesticides are very persistent in the environment, and their residues could have carried over into the developing residential areas.

Pesticides are also used around structures, parks and schools. These may include chemicals that are used in agriculture, and are chemicals with specific target pests, such as termiticides, or more broad-spectrum insecticides such as those used by professional home pesticide applicators and homeowners, and herbicides used by professional landscapers (or applicators) and homeowners.

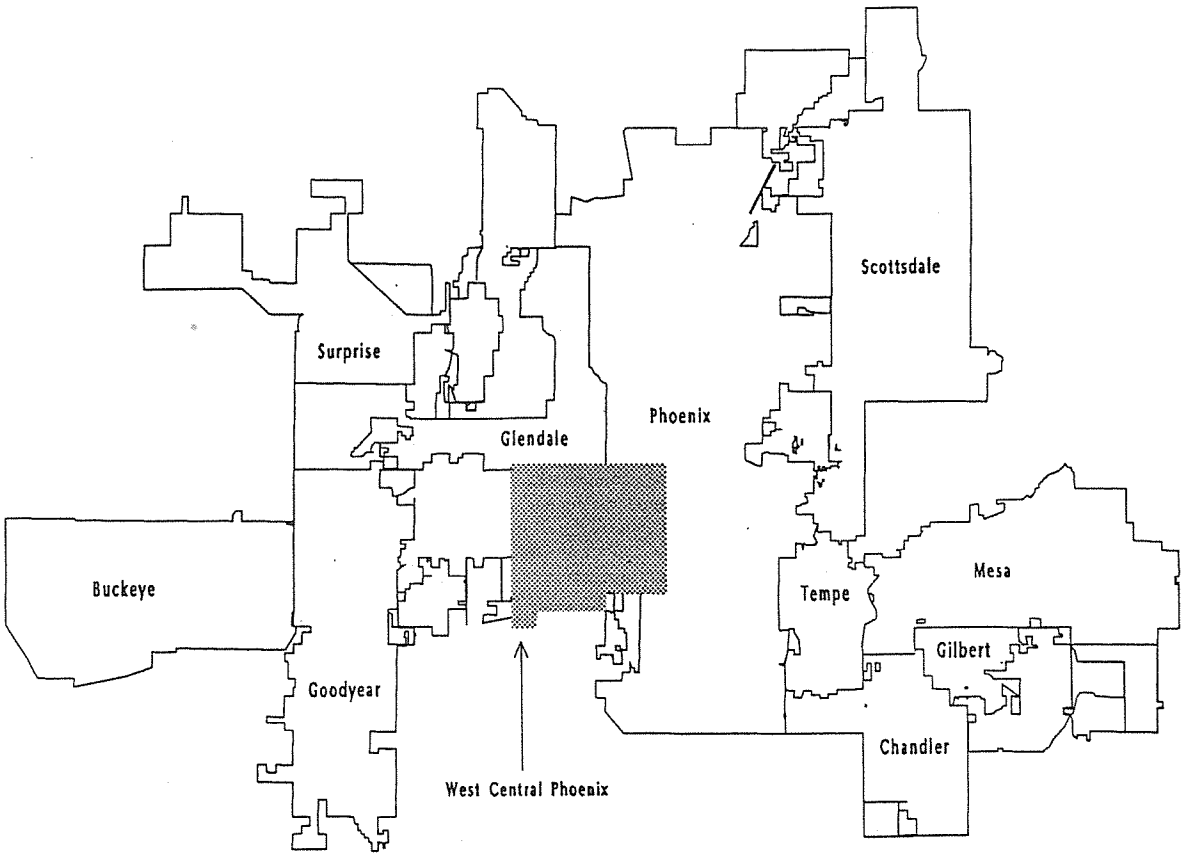
Any historical pesticide application, agricultural or residential, could be of potential concern from a public health standpoint. The risk to inhabitants is a function of the concentration of pesticide residuals in soils and the exposure of inhabitants to the contaminated soil. This study was proposed with the intent of characterizing the residuals of pesticides in soils.

III. **Location of the Study**

The project is located in the western Phoenix metropolitan area. The project boundaries for this study are Camelback Road to the north, the Salt River to the south, 19th Avenue to the east, and 83rd Avenue to the west. The project area covers approximately 62 square miles.

For purposes of this study, the project area is designated as west central Phoenix. The project area in relation to metropolitan Phoenix is illustrated in Figure 1. The project area itself is illustrated in Figure 2.

Figure 1. Project Vicinity Map

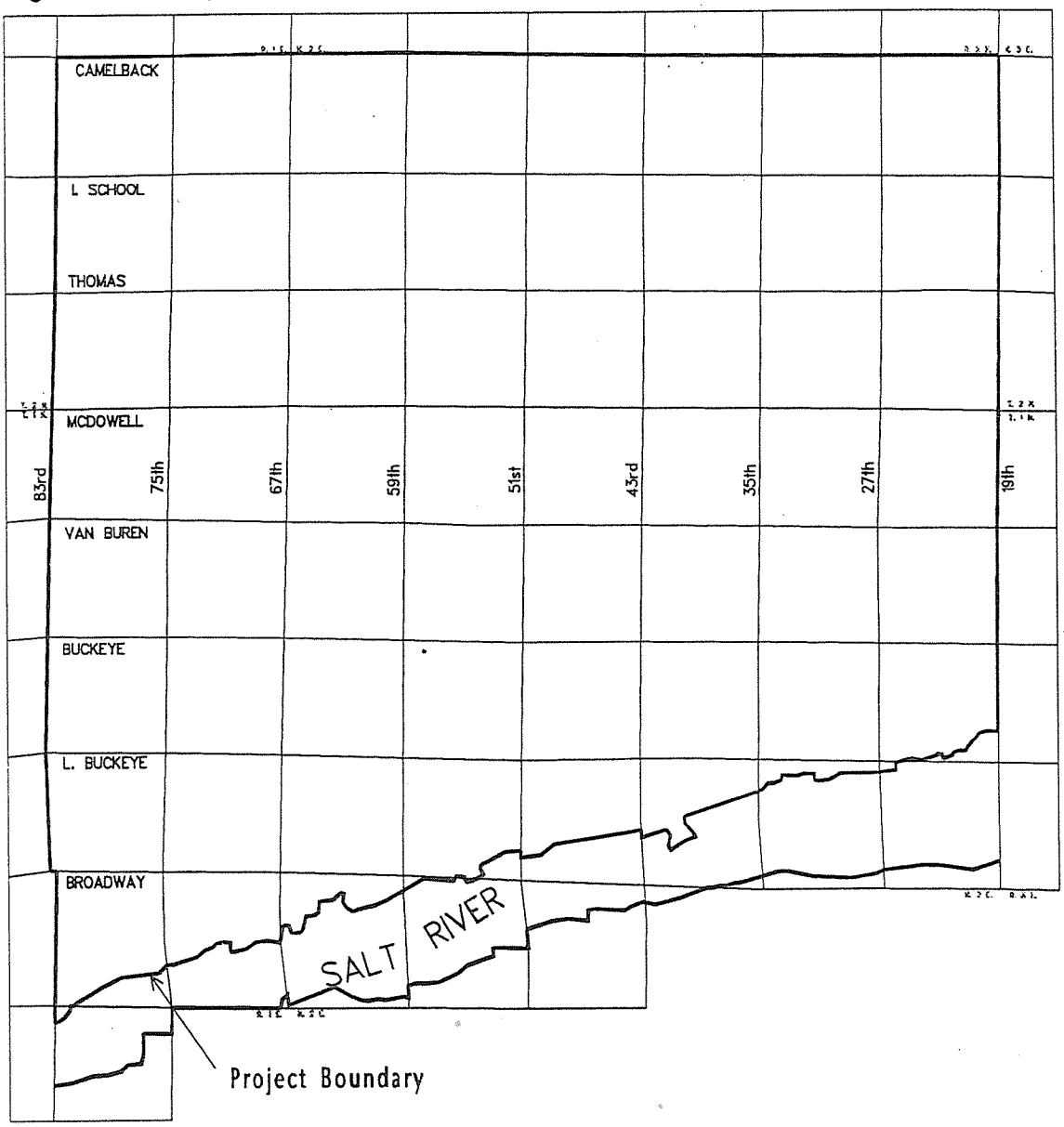


SCALE

10 8 6 4 2 0 10 MILES

10 8 6 4 2 0 16 KILOMETERS

Figure 2. Project Area Map, West Central Phoenix



SCALE

1 1/2 0 1 MILE

1 5 0 1 KILOMETER

IV. **Background Studies and Information**

Several reports have been completed under the direction of Arizona Department of Environmental Quality. These reports provide necessary background for the study of pesticide residuals in soils in west central Phoenix and are described below.

A. Historical Land Use In West Central Phoenix

A study titled West Phoenix Historic Land Use Mapping was prepared by the Arizona Remote Sensing Center, Office of Arid Land Studies, University of Arizona. The study was completed under contract to ADEQ. The study identified changes in land use in west central Phoenix between 1954 and 1985. Land use characterization was accomplished through interpretation of aerial photography from the years 1954, 1958, 1964, 1970, 1976, 1981 and 1985.

The land-use study revealed that west central Phoenix was primarily a rural area west of metropolitan Phoenix in 1954. During that time, the land uses were approximately one-fourth urban and three-fourths agriculture. From 1954 to 1985, west central Phoenix was increasingly urbanized to the point where developed land in 1985 accounted for two-thirds of the land area. Areas that were previously agricultural were converted to residential, commercial, and industrial uses.

Presently, agriculture continues to be the main land use for the outlying rural areas of west central Phoenix. The study assisted ADEQ in the selection of agricultural sample sites, urban sample sites that were previously in agriculture, and sample sites that have no history of agricultural use.

Figure 3 illustrates the land uses in west central Phoenix in 1954, depicting the large areas of agricultural activity. Figure 4 illustrates land uses in west central Phoenix in 1985, clearly showing the significant conversion of agricultural land into urban use. Figure 5 is a composite of Figures 3 and 4, which shows areas which did not undergo a change in land use during the period 1954-1985.

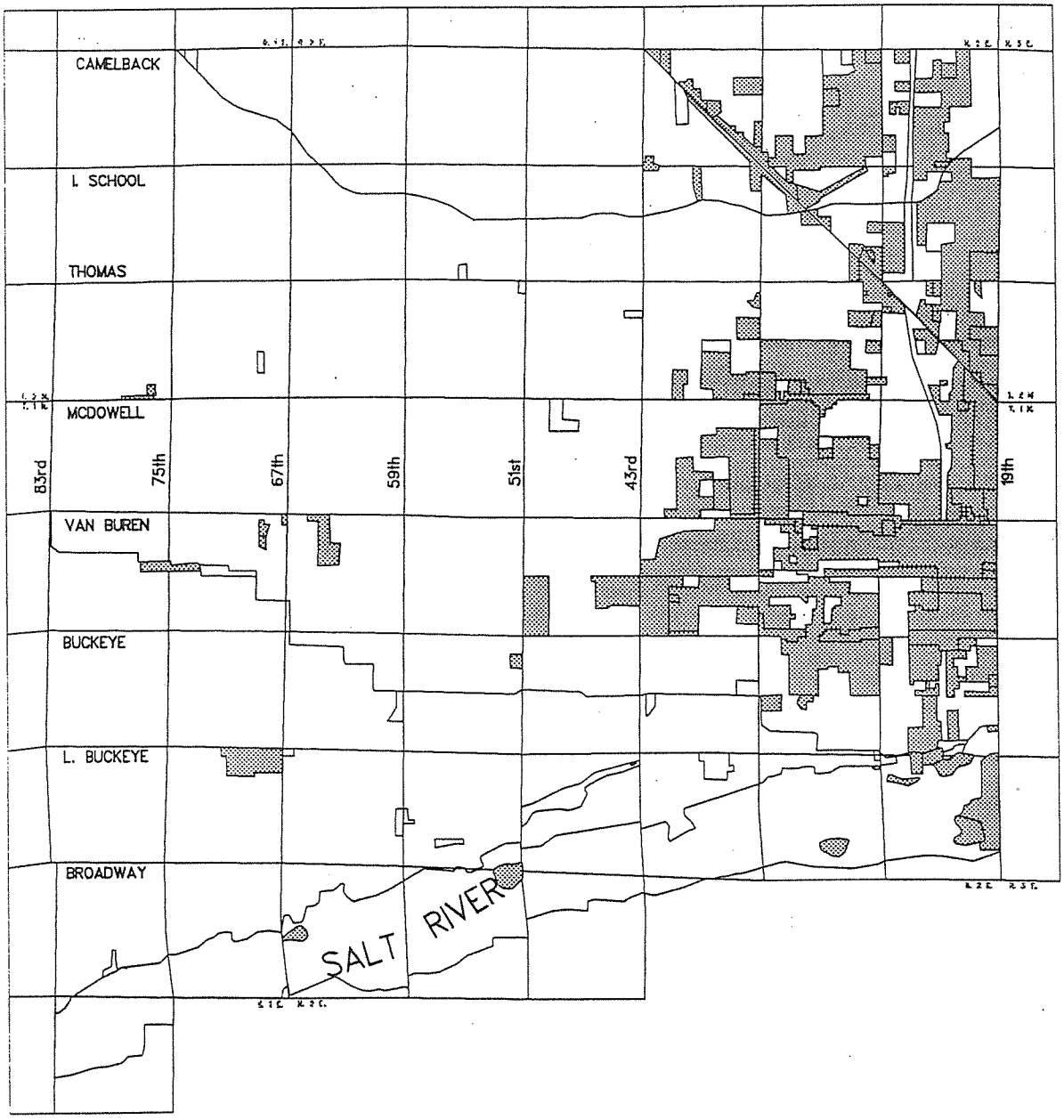
B. Historical Pesticide Use

1. Agricultural Pest Control

The State Pesticide Coordinator's Office of the University of Arizona Cooperative Extension Service studied agricultural pesticide use patterns in Arizona. This project was also conducted under contract with ADEQ. The study culminated in a draft report of December 1987 titled A Survey of Historical and Current Agricultural Pesticide Use in Arizona. This report is currently being updated.

As the study reports, pesticide research led to the development and regulation of thousands of products for pest control after World War II. The compounds widely used in Arizona following WWII, and through the 1950s and 1960s, were the chlorinated hydrocarbons. They included the pesticides DDT, toxaphene, and dieldrin. These compounds are very persistent in the environment and toxic to non-target organisms. Increasing regulation of chlorinated hydrocarbons encouraged the development of less environmentally persistent compounds including organophosphates, carbamates, and synthetic pyrethroids.

Figure 3. Land Use Map - 1954, West Central Phoenix



Urbanization

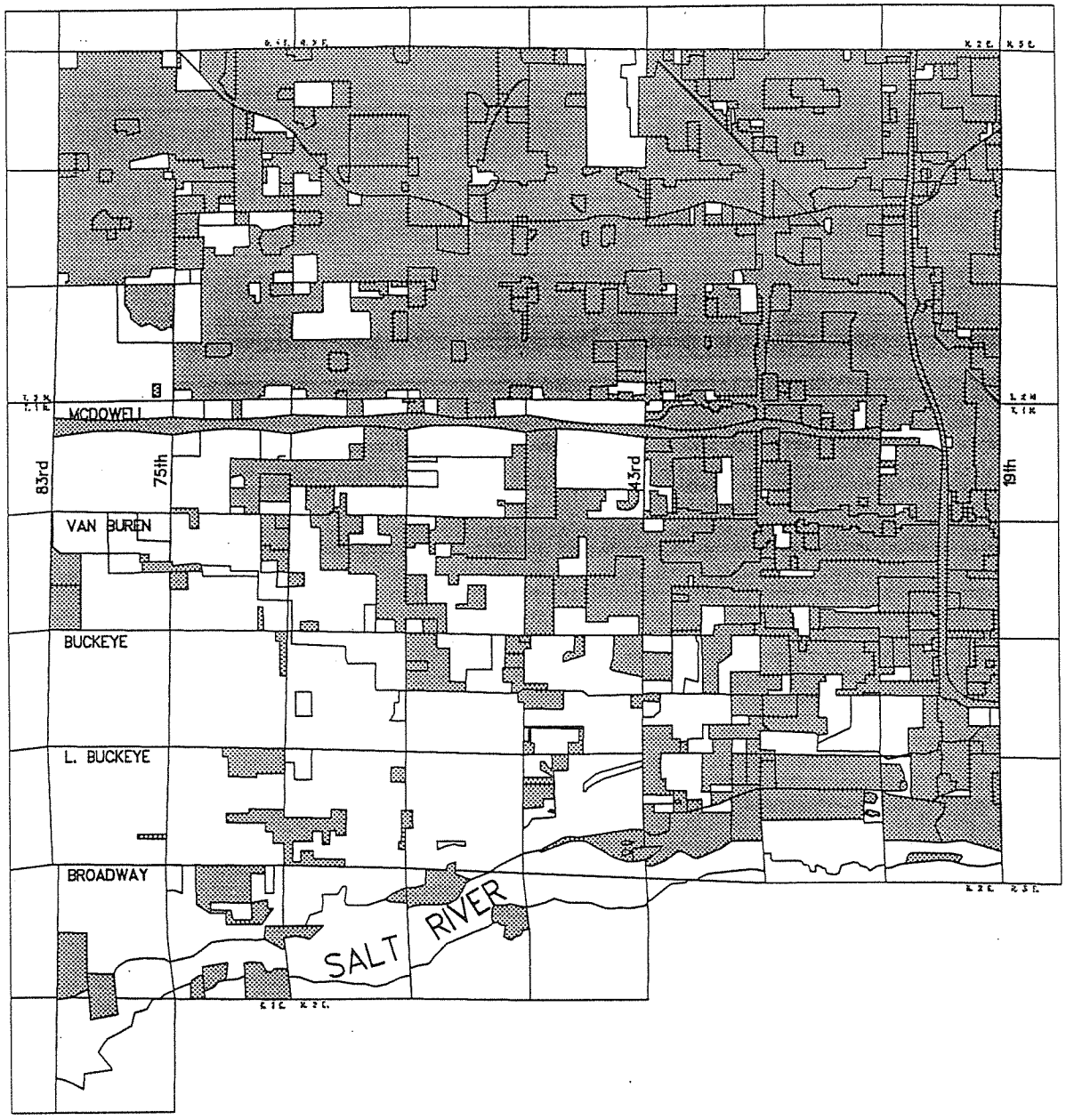
Agriculture/Open Space

SCALE

1 1/2 0 1 MILE

1 5 0 1 KILOMETER

Figure 4. Land Use Map - 1985, West Central Phoenix



Urbanization

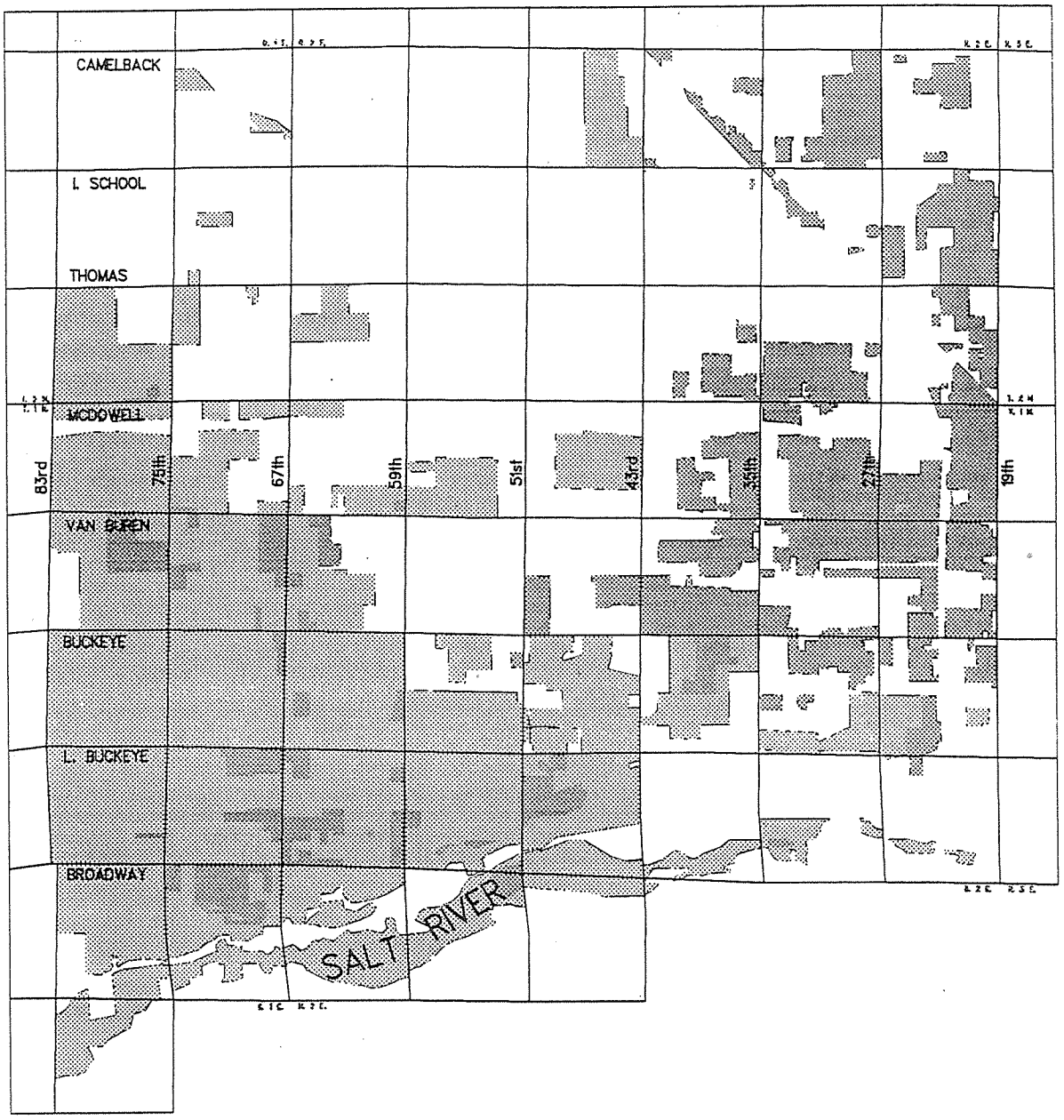
Agriculture/Open Space

SCALE

1 1/2 0 1 MILE

1 5 0 1 KILOMETER

Figure 5. Unchanged Land Use 1954-1985 - West Central Phoenix



Urbanization (1954)

Agriculture/Open Space (1954)

SCALE

1 1/2 0 1 MILE

1 5 0 1 KILOMETER

According to the study, Arizona was the first state to place a moratorium on DDT in the 1960s. Increasing public concern over heavy pesticide use resulted in federal legislative action during the 1970s. Almost all chlorinated hydrocarbons were cancelled for agricultural uses in the 1970s. The availability of certain herbicides and synthetic pyrethroid insecticides resulted in substantially changing the pesticide use patterns and decreasing the overall cropland pesticide load. Pesticide trends in the 1980s resulted in a decreased pesticide total load because of lower application rates and a combination of new technologies with traditional pest control strategies.

The study indicated that approximately 350,000 acres of cropland was in production as of 1987 in Maricopa County. The most significant crop was cotton. In 1980, the amount of cotton acreage was at its highest level at 239,500 acres.

Cotton is one of the most intensive users of pesticides. Other crops cultivated in Maricopa County, which also require pesticides in varying amounts, include barley, sorghum, wheat, alfalfa, sugarbeets, lettuce, and citrus. These crops were likely grown in the west central Phoenix area as well.

2. Structural Pest Control

Structural pest control involves the application of pesticides to the exterior and interior of buildings as well as to lawns and landscaped areas around homeowner properties and commercial buildings. There are two classes of application. These are long-term and short-term pest control.

Long-term pest control is defined as the application of pesticides during the construction of new buildings. For residences and/or commercial properties, pesticides were applied beneath the foundation prior to pouring of a concrete slab. During the 1950s and 1960s, the pesticides used were the organochlorines and cyclodienes. Chlordane was most frequently used cyclodiene. These pesticides have a long degradation period which provide long-term effective termite control lasting several years.

Since cancellation of the organochlorines and cyclodienes, alternative pesticides used for long-term control were more toxic but had a shorter soil half-life or degradation period. Many of the newer compounds are photo degradable, that is, if exposed to sunlight, they degrade in a few hours.

The alternative materials now in use, therefore, must be applied just prior to the pouring of concrete foundations. The long-term control provided by the organochlorine pesticides was significantly greater than the control provided by the materials currently available.

Residential and commercial properties may have to be periodically treated for continued protection against termites.

Short-term pest control involves application of various pesticides to the yards, gardens, foundations, and interiors of residential and commercial structures. Materials applied are used to manage weeds, crickets, spiders, cockroaches, and related household pests. The pest control operator frequently sprays residential properties on a regular or seasonal basis. This frequency can range from every month to once a year. Since these pesticides are exposed to air, wind, moisture, and sunlight, they degrade more quickly than pesticides applied beneath foundations for termites.

It would not be surprising to find higher residual amounts of pesticides at the foundations of residences than in the yard and/or gardens. Sampling residential or commercial buildings at foundations and within the yards is recommended to substantiate the soil residual patterns associated with the customs of the pest control. In addition, these sampling patterns would permit ADEQ to identify the differences in residues from pesticides applied to foundations and yard or landscaped areas.

C. Children's Activity Patterns

The Department of Environmental Quality contracted with Dr. James Sell with the School of Natural Resources, University of Arizona, to conduct a study on children's activity patterns in west central Phoenix (Sell, 1989). The report was intended to assist the Department in identifying sampling locations based on exposure potential as a function of children's preferences for play sites.

The study involved a two-step process of 1) examining existing literature on the subject to identify previously documented play site preferences, and 2) surveying activity areas in the west central Phoenix area specifically through personal interviews with children and mail-out questionnaires to parents. The study concluded that children in the west central Phoenix area exhibited the highest preference for residential yards over other potential sites. The yards were not only the preferred locations, but also contained the widest variety of activities. Public parks and recreational areas were the second preference among children for play. Other areas which followed yards and public parks were streets/paths/alleys, natural/vacant areas and parking lots.
The study recommended that possible sample sites be classified into public and private places. The public areas would include school playgrounds and parks; the private areas would include residential yards.

D. Health Based Guidance Levels (HBGLs)

A listing of draft Health Based Guidance Levels (HBGLs) was developed by the Arizona Department of Health Services (ADHS) and published by ADEQ in September 1990. Of the 230 chemicals listed, many included pesticide compounds. The HBGLs are applicable only to the ingestion of water and soil.

Although the levels have no official status with respect to enforcement as cleanup standards, they are useful as a reference in environmental work. The HBGLs were helpful in this study in determining the significance of the amount of any pesticide compounds found in the soils of west central Phoenix.

V. **Project Approach**

The soil sampling and analysis program for west central Phoenix was conducted in two phases. Phase I consisted of sampling agricultural sites to identify baseline levels of pesticide residuals which may have resulted from agricultural use. This effort was intended to indicate which residuals may be encountered in residential areas that were developed on previously agricultural sites.

Phase II was designed on the basis of results from Phase I, plus information from other sources. The focus of Phase II was soil sampling in residential areas to determine the extent to which chemical residuals were present in locations where children would be exposed. With the results from Phase I sampling, it would be possible to identify to what extent pesticide contamination of soil was from agricultural versus structural uses.

Information from various sources was used to formulate the sample plans for Phases I and II. Such information included:

- Reports:

  West Phoenix Historic Land Use Mapping 1954-1985, Office of Arid Land Studies, University of Arizona

  A Survey of Historical and Current Agricultural Pesticide Use in Arizona, University of Arizona Cooperative Extension, December 1987

  Use of Children's Activity Patterns in the Development of a Strategy for Soil Sampling in West Central Phoenix (Draft), James L. Sell, University of Arizona, 1989

- Interviews and communication with:

  Arizona Department of Agriculture and Horticulture(now AZ Department of Agriculture)
  Local Extension Services
  West central Phoenix residents
  Arizona Structural Pest Control Commission
  University of Arizona
  Pesticide Coordinator's Office, University of Arizona

- Documentation on toxicological effects, etc. from ADHS and the US Environmental Protection Agency (EPA)

- Map Sources:

  U.S. Geological Survey Topographic Maps
  University of Arizona Land Use Study Maps
  US Soil Conservation Service Maps
  Arizona State Highway Map

Flow charts illustrating the sampling process for Phases I and II can be found in Figures 6 and 7. Summaries of the individual sample plans for Phases I and II are presented in the following section.

Figure 6. Sample Process - Phase I/Agricultural Areas

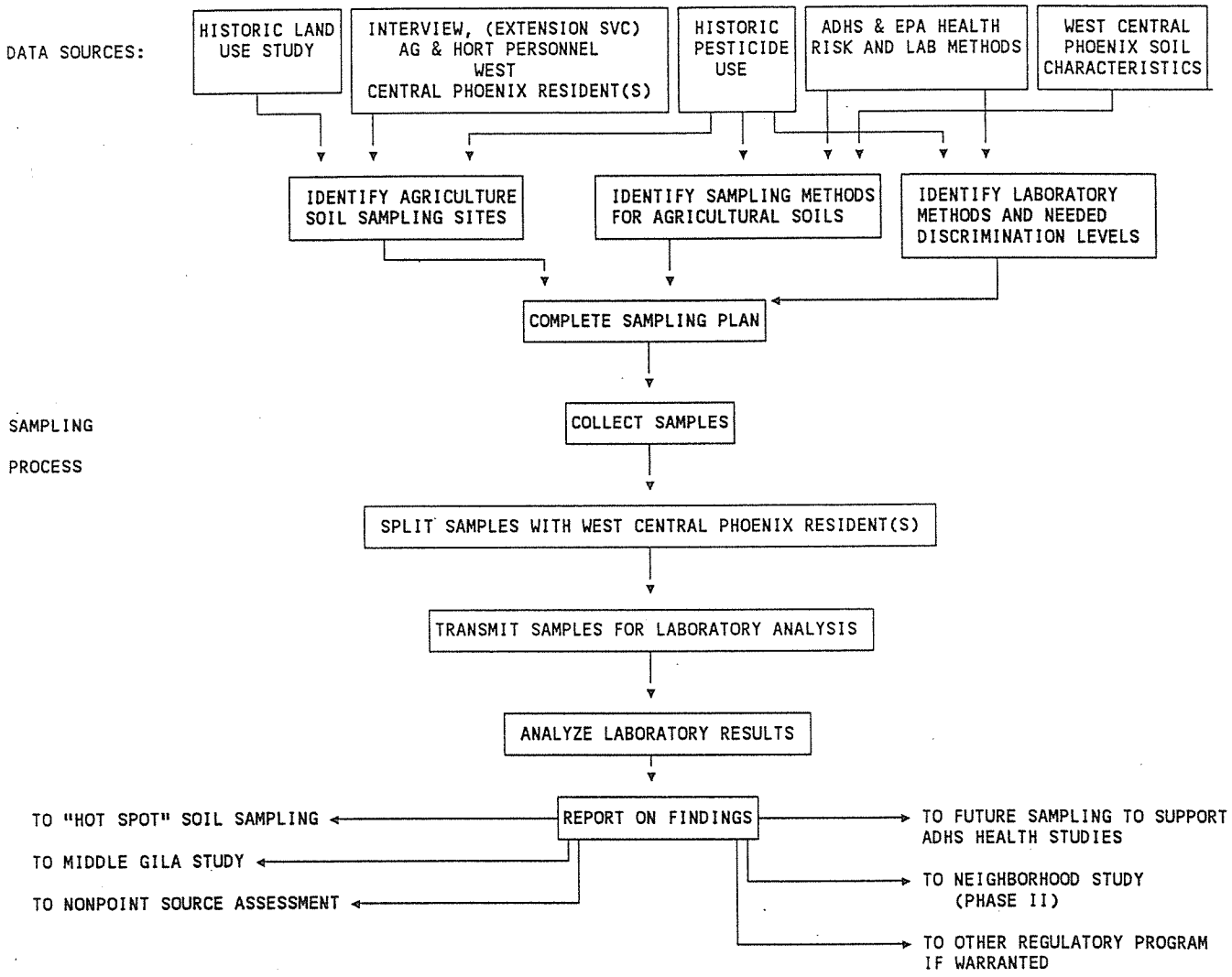
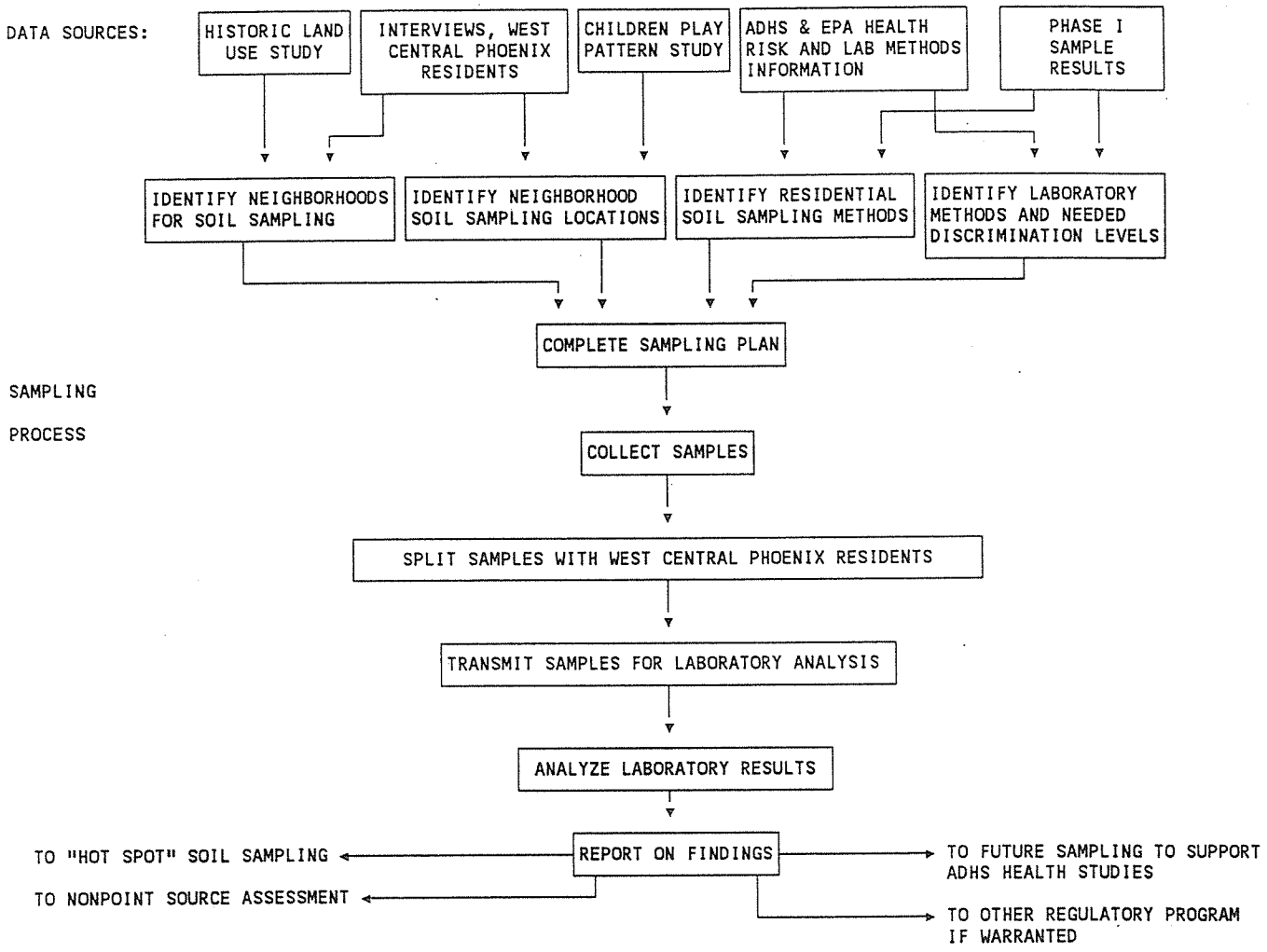


Figure 7. Sample Process - Phase II/Residential Areas



VI. **Sample Plan Summaries**

Sample plans were created prior to each phase of the study. These plans were distributed through ADEQ and were ultimately made available to the public. The following discussion summarizes the sample plans for each phase.

A. Phase I - Agricultural Areas

Phase I explored the nature of residuals in areas that were in "active" agriculture. The sample plan identifies sample locations and size, timing of sampling, pesticides to be analyzed, and methods for sample collection. These are discussed below.

1. Sample Locations

Ten sample locations were identified for the Phase I sample plan. Six of the ten locations were in agriculture in 1985 and had been in constant agricultural use prior to 1985 (through the period of the Historic Land Use Study). Those six locations represented areas of greatest potential accumulation of agricultural pesticide residuals. They were designated as sites 5 through 10. Of the six agriculture sample sites, two (9 and 10) were selected in response to input from west central Phoenix residents. They were historically in agricultural use but were in various stages of development at the time of sampling. Undisturbed areas at those sites were sampled.

Additionally, two agricultural locations from outside the west central Phoenix study area were selected as controls. They were designated as sites 3 and 4.

Of the eight locations within the study area, two were selected that were not in agriculture from 1954 to present. They were to serve as controls to compare results from agricultural lands to non-agricultural areas. These two sites were designated sites 1 and 2. They consisted of a cemetery and a school.

The ten sample locations are listed in Table 1, and illustrated on a map in Figure 8. The land use history of the sample sites from 1954 to 1985 is found in Table 2.

2. Number of Samples

There were 36 sub-samples taken from each sample location during Phase I. The 36 sub-samples were mixed to form a composite sample. This was done to give residue levels that were statistically representative of overall levels for a particular site. The statistical basis for using a 36 sample composite is provided in Appendix B.

Table 1. List of Sample Sites - Phase I

SAMPLE NUMBER	NAME OF SITE	LEGAL DESCRIPTION
MSS 1	Greenwood Cemetary	T1N-R2E-W1-CAB
MSS 2	Alhambra Elem. School	T2N-R2E-S22-DBB
MSS 3	Olive West (Outside West Central Phoenix)	T3N-R1E-S26-CCC
MSS 4	England Property (Outside West Central Phoenix)	T2S-R5E-S2-CBC
MSS 5	Conovaloff	T2N-R1E-S35-BAA
MSS 6	Roth	T1N-R1E-S11-CAA
MSS 7	O'Connor	T1N-R1E-S12-DCC
MSS 8	City of Phoenix	T1N-R2E-S30-BCC
MSS 9	Santa Fe Ind. Park	T2N-R2E-S21-ACC
MSS 10	Desert West Park	T2N-R2E-S31-ACA

Figure 8. Sample Locations - Phase I

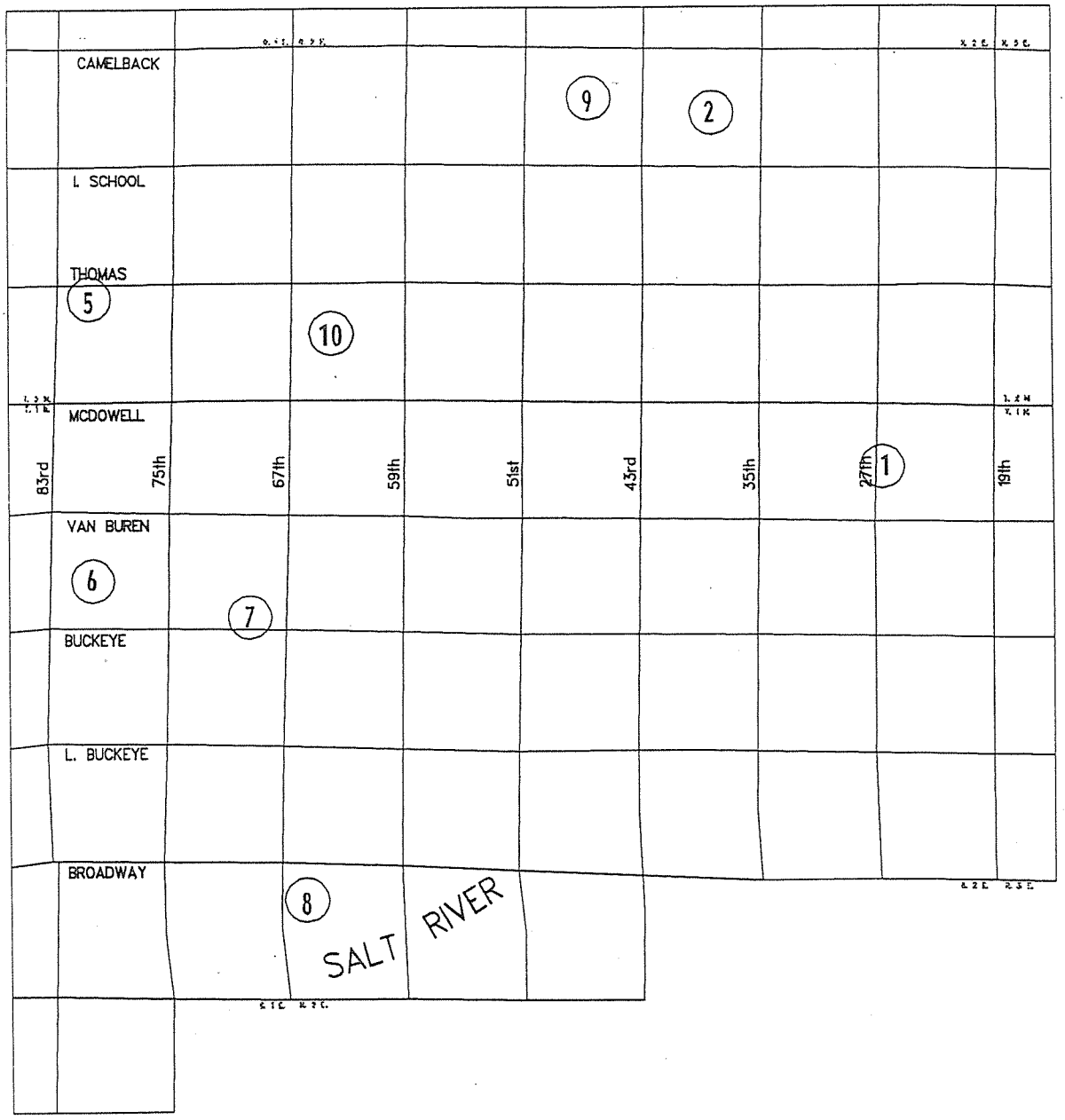


Table 2. Land Use History Agricultural Sample Sites
West Central Phoenix

YEAR	MSS 1	MSS 2	MSS 3*	MSS 4*	MSS 5	MSS 6	MSS 7	MSS 8	MSS 9**	MSS 10**
1985	CEMETERY	SCHOOL			AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE
1981	CEMETERY	SCHOOL			AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE
1976	CEMETERY	SCHOOL			AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE
1970	CEMETERY	SCHOOL			AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE
1964	CEMETERY	SCHOOL			AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE
1958	CEMETERY	SCHOOL			AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE
1954	CEMETERY	SCHOOL			AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE

NOTES:

* MSS 3 AND MSS 4: THESE ARE AGRICULTURAL SAMPLE SITES OUTSIDE OF THE WEST CENTRAL PHONEIX STUDY AREA.

** MSS 9 AND MSS 10: ALTHOUGH THEY WERE AGRICULTURAL IN 1985, THEY WERE BEING CONVERTED TO URBAN USE AT THE TIME OF THIS STUDY.

3. Timing

The samples were collected on a daily basis. Two to three sites were sampled daily until all ten sites were sampled. Samples were shipped on ice to the lab at the end of each day. The sampling took place from March 1 to March 14, 1989.

4. Pesticides Selected for Analysis

Agricultural pesticide chemicals were compiled originally from pesticide sales and use information given in A Survey of Historical and Current Agricultural Pesticide Use in Arizona (1987). This list of pesticides was compared with a variety of food and fiber crops grown in the study area. An initial list was selected by ADEQ and submitted to ADHS for evaluation of each pesticide's carcinogenic, mutagenic and teratogenic characteristics. This list eliminated those pesticides that have been documented as not being carcinogenic, mutagenic and/or teratogenic. Other pesticides were eliminated after consulting with the U.S. Environmental Protection Agency (EPA). These included volatiles (EDB, DBCP, DDT, EPTC) and inorganics (cryolite, copper sulfate and sulfur). Volatiles would not be expected to be present and the inorganics occur naturally. ADEQ added 13 pesticides back onto the list for analysis on the basis of acute toxicity. The list of analytes was finally narrowed based on the availability of analytical methodologies for detection of the pesticides of concern.

Many of the pesticides identified were used in the production of cotton as it historically has been the most significant crop in Maricopa County. As much as nearly one-half of the farmland within the study area had been used for this crop.

The pesticides under study also have been used as insecticides and herbicides for the cultivation of barley, sorghum, wheat, alfalfa, sugarbeets, lettuce and citrus. Of the pesticides, chlordane and heptachlor were primarily applied for termite control.

The list of pesticides intended for analysis in this study during Phase I are found on Table 3.

5. Sample Collection Methods

At each sample location, a grid was plotted and staked. Thirty-six sampling points were chosen per grid (see Appendix A for explanation of sampling method). Within the grid, sampling points were placed 50 feet apart for all but one site (site 2). This site had sampling points placed 25 feet apart because of limited available space. All sample grids were rectangular in shape. All of the sample grids (except site 2) measured 100 feet by 550 feet.

Table 3. Pesticides Selected for Study - Phase I

INSECTICIDES		
Aldicarb	Disulfoton	Methomyl
Azinphos-Methyl	Endosulfan I	Methoxychlor
Benzene	Endosulfan II	Methyl Parathion
Carbaryl	Endosulfan Sulfate	Monocrotophos
Carbofuran	Endrin (Aldehyde)	Parathion
Chlordane	Endrin	Phorate
DDT	EPN	Phosphamidon
DDD	ethion	Profenofos
DDE	Fenvalerate	Sulprofos
Dicrotophos	Heptachlor	Toxaphene
Dieldrin	Heptachlor Epoxide	Trichlorfon
Dimethoate	Lindane	
HERBICIDES		
2,4-D	Dinoseb	Profluralin
Arsenic Acid	Diuron	Pronamide
Atrazine	Endothall	Propham
Bensulide	Monuron	Silvex
Bromacil	Napropamide	Tebuthiuron
Cyanazine	Paraquat	Trifluralin
DCPA	Pendimethalin	
OTHER (FUNGICIDES, etc.)		
Captan	Dicofol	Terrazole
DEF	Maneb	

Prior to sampling, all soil collecting equipment was decontaminated at ADEQ's 2655 E. Magnolia facility. A tarp was placed at each sampling area so the decontaminated equipment would not rest on the ground.

Soil samples were collected from the top six inches of soil using a T-handle stainless steel soil probe or a Veihmeyer soil sampling tube.

The soil from each sub-sample was transferred to a stainless steel mixing bowl. The soils were completely mixed (for ten minutes), then placed in I-Chem Quality Control glass jars, sealed and prepared for shipment to the laboratories. Split samples were also prepared for representatives of Mothers of Maryvale and for site owners upon request.

At each sample site, the soil collecting equipment was decontaminated by rinsing, using detergents and solvents. Decontamination was performed between each sampling site. To preserve quality control, two duplicate samples were taken at random for every ten samples collected, and eight split samples were taken from four of the ten sites and sent to different laboratories for verification. Lab quality assurance was accomplished using surrogate spikes, matrix spikes, duplicates, reagent blanks, and lab calibration checks.

Chain of custody procedures were followed for all sample and split sample submittals to the laboratories.

6. Laboratories Selected

The contract laboratory selected to analyze all of the samples for pesticide residuals was Brown and Caldwell Laboratories located in Pasadena, California. The split samples for MSS 2, MSS 4, MSS 5 and MSS 7 were sent to the U.S. Environmental Protection Agency (EPA) in Las Vegas, Nevada. These samples were analyzed by their contract laboratory, Pacific Analytical in Carlsbad, California.

B. Phase I Resample - Agricultural Areas

Resampling locations were selected based on the preliminary laboratory results from samples taken during early March 1989. The main objective for the resampling was to verify pesticide detections and concentrations, primarily for the compound strobane (toxaphene). The initial lab results indicated strobane (toxaphene) residues which were high enough to warrant resampling for verification.

1. Sample Locations

Three Phase I locations were selected for resampling. These were sites that exhibited the highest concentration of strobane (toxaphene) residues, and which were still fallow. They are listed in Table 4, and illustrated on a map in Figure 9.

A sample was also taken from a non-agricultural (desert) site with little or no evidence of human activity. This was the control sample.

2. Timing

The resampling took place on June 26, 28, 29, and 30 of 1990.

3. Pesticides Selected for Analysis

Based upon the previous laboratory results, the list of pesticides analyzed in the resample effort included arsenic acid, toxaphene, DDT, DDD, DDE, endrin, endosulfan, and lindane. There were also tests for Total Organic Carbon and soil texture.

4. Resample Collection Techniques

The resample collection techniques were similar to those used during initial sampling in March 1989. In addition to the collection of composite samples, however, nine discrete samples were collected. At two sites, MSS 5 and MSS 10, three randomly selected discrete samples were collected within the grid of 36 samples. At site MSS 5, three randomly selected discrete samples were selected outside of the grid but within the boundaries of the site. The discrete samples were taken to test the assumption of field uniformity by comparing the composite result to discrete results within and outside of the sample grid. These randomly selected samples were placed directly into sample containers from randomly designated sub-samples instead of mixing them into a composite sample.

A representative of Mothers of Maryvale was given three split samples from the composite samples and nine duplicate samples from the discrete samples.

The chain of custody was identical to the March 1989 sampling.

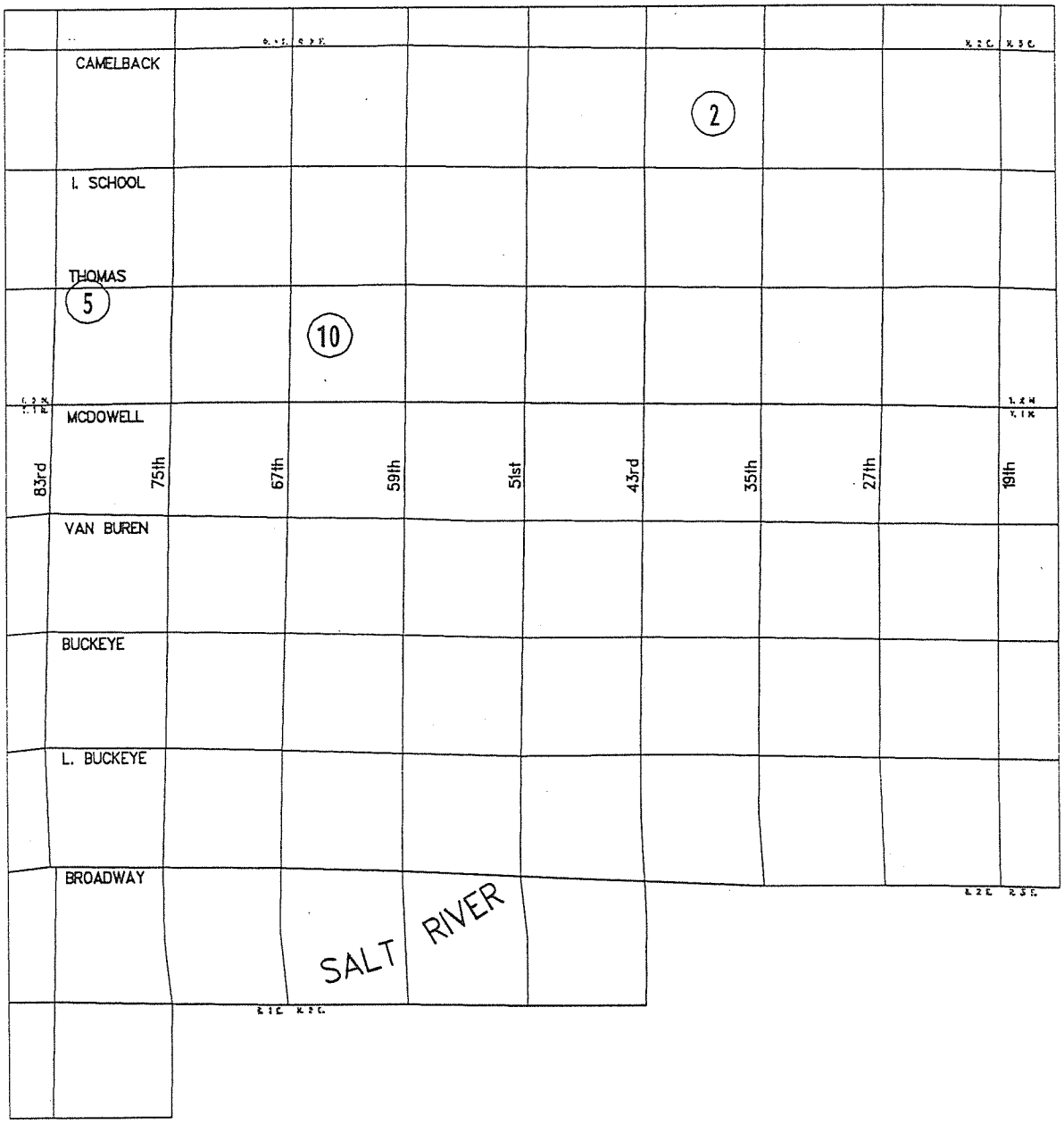
5. Laboratory Selected

The laboratory assigned to analyze for the pesticide residues, Total Organic Carbon, and soil texture was Analytical Technologies in Tempe, Arizona.

Table 4. List of Resample Sites - Phase I

SAMPLE NUMBER	NAME OF SITE	LEGAL DESCRIPTION
MSS 2	Alhambra Elem. School	T2N-R2E-S22-DBB
MSS 5	Conovaloff	T2N-R1E-S35-BAA
MSS 10	Desert West Park	T2N-R2E-S31-ACA

Figure 9. Resample Locations - Phase I / Agricultural Areas



SCALE

1 1/2 0 1 MILE

1 5 0 1 KILOMETER

C. Phase II - Residential Areas

The data from the Phase I sampling was used to help determine locations and pesticide analytes for sampling for Phase II. This phase sampled pesticide residues in urban locations that were once agricultural.

1. Sample Locations

A total of 17 sites were selected for sampling. Sites were selected based on previous land use history, current land use type and proximity to areas in west central Phoenix having a perceived history of health problems. Representatives of Mothers of Maryvale (Ms. Melody Baker and Ms. Shirley Marotta) were indispensable in locating potential residential sampling sites.

Of the 17 sites, eight were residences, two were parks, five were schools, and two were control sites in Tempe which included a home and a school. All but two of the Phase II sample sites in west central Phoenix were in historical agricultural use as far back as 1954 and were later developed for urban use. About one-half of the west central Phoenix sample sites were converted from agriculture to urban use between 1954 and 1964. The sites are listed in Table 5 and shown on a map in Figure 10. The land use history of the sample sites from 1954 to 1985 is shown in Tables 6 and 7.

2. Number of Samples

At the residential sites, there were up to four possible sample locations: the lawn area, garden, play area (two depths), and building foundation. The backyard was sampled as a composite; if the volume wasn't sufficient then the front yard was also sampled and added to the overall yard composite sample. If a distinct play area was visible, it was sampled as its own composite, and an additional composite was taken at a depth of 6"-12". A composite sample was taken around the base of the structure. Garden areas were also composite sampled since children will be found digging in them.

Each composite consisted of between 25 - 30 discrete cores. This composite volume provided a representative sample of the area.

3. Timing

The samples were collected on a daily basis. The sampling took place from June 18 - 29, 1990.

Table 5. List of Sample Sites - Phase II

	RESIDENCES
1.	4200 block of North 49th Avenue
2,	4400 block of West Weldon Lane
3.	1100 block of North 29th Avenue
4.	3100 block of North 52nd Parkway
5.	6200 block of West Monterrey Way
6.	3700 block of West Verde Lane
7.	6300 block of West Sells Drive
8.	5300 block of West Coronado Street
	PUBLIC AREAS
9.	Seuño Park
10.	Marivue Park
11.	W.R. Sullivan School
12.	John F. Long School
13.	Palm Lane School
14.	Andalucia School
15.	St. Vincent de Paul School
	CONTROL SITES
16.	Meyer School, Tempe
17.	Residence, 1000 block of East Fairmont

Table 6. Land Use History - School/Parks Sample Sites
West Central Phoenix

YEAR	(9) SUEÑO PARK	(10) W.R. SULLIVAN	(11) JOHN F. LONG	(12) MARIVUE PARK	(13) PALM LANE	(14) ST. VINCENT DE PAUL	(15) ANDALUCIA
1985	PARK	SCHOOL	SCHOOL	PARK	SCHOOL	SCHOOL	SCHOOL
1981	PARK	SCHOOL	SCHOOL	PARK	SCHOOL	SCHOOL	SCHOOL
1976	PARK	SCHOOL	SCHOOL	PARK	SCHOOL	SCHOOL	SCHOOL
1970	AGRICULTURE	SCHOOL	SCHOOL	PARK	AGRICULTURE	SCHOOL	SCHOOL
1964	AGRICULTURE	SCHOOL	SCHOOL	PARK	AGRICULTURE	SCHOOL	SCHOOL
1958	AGRICULTURE	SCHOOL	AGRICULTURE/ RESIDENTIAL*	AGRICULTURE	AGRICULTURE	AGRICULTURE	SCHOOL
1954	AGRICULTURE	SCHOOL	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE

▦ AGRICULTURAL USE

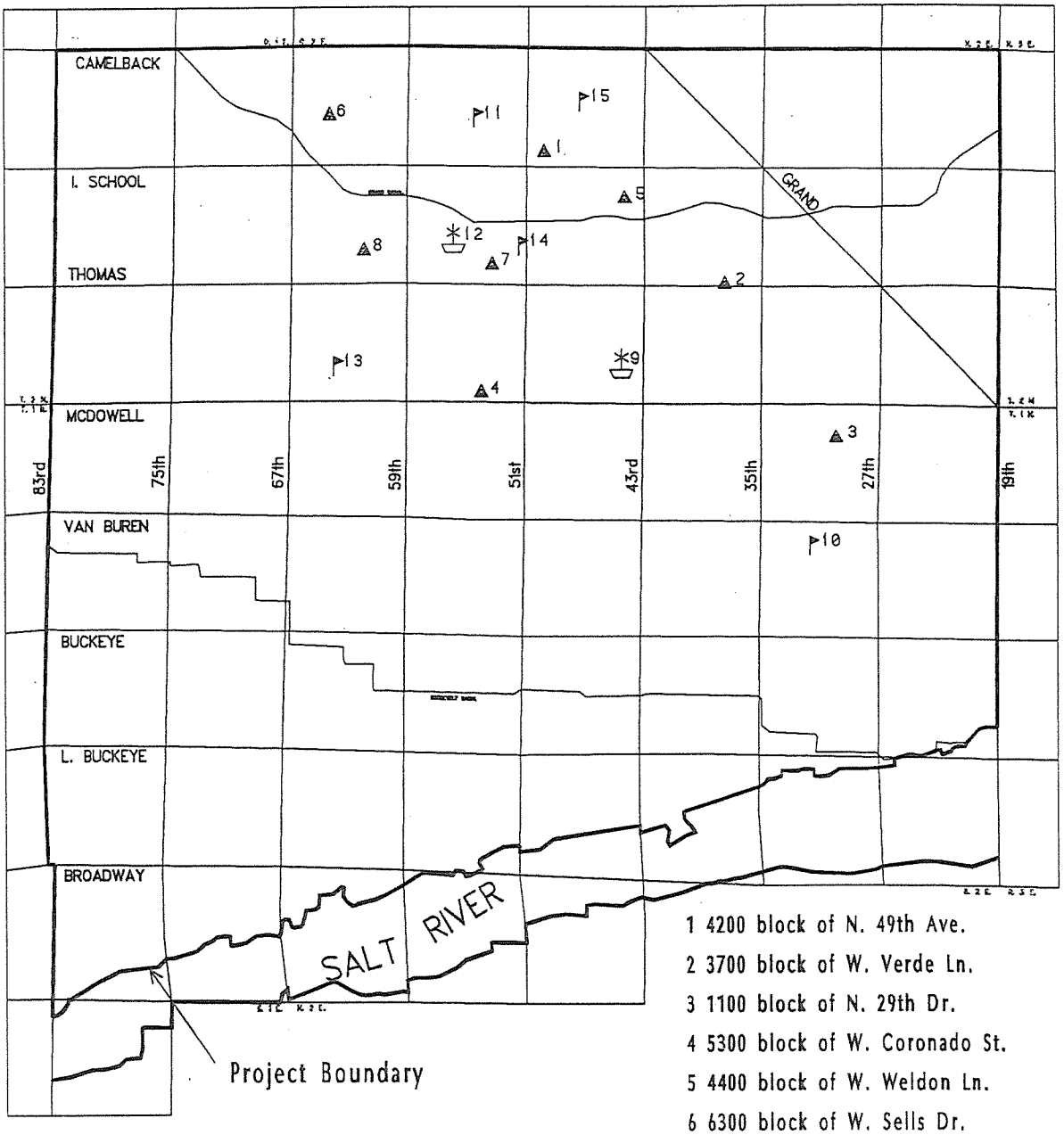
* THE SITE WAS PARTLY IN AGRICULTURE AND PARTLY IN RESIDENTIAL USE.

Table 7. Land Use History - Residential Sample Sites
West Central Phoenix

YEAR	(1) 4200 N. 49TH AVENUE	(2) 3700 W. VERDE LANE	(3) 1100 N. 29TH DRIVE	(4) 5300 W. CORONADO	(5) 4400 W. WELDON LANE	(6) 6300 W. SELLS DRIVE	(7) 3100 N. 52ND PARKWAY	(8) 6200 W. MONTERREY WAY
1985	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL
1981	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL
1976	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL
1970	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	AGRICULTURE	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL
1964	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	AGRICULTURE	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL
1958	RESIDENTIAL	RESIDENTIAL	RESIDENTIAL	AGRICULTURE	RESIDENTIAL	AGRICULTURE	AGRICULTURE	AGRICULTURE
1954	AGRICULTURE	AGRICULTURE	RESIDENTIAL	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE	AGRICULTURE

▦ AGRICULTURAL USE

Figure 10. Sample Locations - Phase II



Legend

- School
- Park
- Residence

SCALE

1/2 0 1 MILE

1 5 0 1 KILOMETER

1 4200 block of N. 49th Ave.
2 3700 block of W. Verde Ln.
3 1100 block of N. 29th Dr.
4 5300 block of W. Coronado St.
5 4400 block of W. Weldon Ln.
6 6300 block of W. Sells Dr.
7 3100 block of N. 52nd Pkwy.
8 6200 block of W. Monterrey Wy.
9 Sueno
10 WR Sullivan
11 John F. Long
12 Marivue
13 Palm Lane
14 St. Vincent de Paul
15 Andalucia

4. Pesticides Selected for Analysis

The rationale for selecting pesticides for the Phase II study was based on many factors. An original list of target pesticides was constructed based on the results from the Phase I agricultural study. Pesticides which were detected during Phase I were automatically identified for Phase II analysis. The list was augmented with pesticides which are used for home use and by professional applicators. These pesticides were identified by surveying local garden shops and through consultation with the Structural Pest Control Commission.

Of all the chemical agents used, those which are known as probable carcinogens were the ones selected for analysis. Thirteen pesticides were selected for analysis which included acephate, acifluorfen, aldrin, captan, chlordane, dieldrin, DDT, DDVP, endrin, heptachlor, heptachlor epoxide, propoxur, and toxaphene.

5. Sample Collection Methods

Prior to sampling public areas, sample locations were staked out on a grid system. In all cases, large play fields (softball, soccer, etc.) were sampled in this manner. The dimensions of the play fields determined the space between stakes.

The samples were obtained from a 0"-6" depth except for play areas at private residences or sand-covered playgrounds where they were sampled separately at 0"-6" and 6"-12" depths (where practical).

The samples were collected, processed, and documented similar to the methods for Phase I.

Five duplicate samples were taken at random. Splits were taken for site owners or representatives as requested. Splits of all samples were also provided for representatives of Mothers of Maryvale.

As an additional measure of quality assurance, six soil samples were submitted as a combination of one soil blank and five discrete spikes using five of the pesticides studied. The concentration of each spike was known to ADEQ, not to the laboratory.

6. Laboratory Selected

The contract laboratory assigned to analyze the pesticide residues was Analytical Technologies, Inc. located in Tempe, Arizona.

VII. **Sample Results and Analysis**

A. Phase I Results and Discussion

1. Phase I Sampling

The results of the Phase I sampling, as reported by the labs, are given in Table 8. There were a total of 63 compounds tested. The compounds acephate (an insecticide) and 2,4-DB (an herbicide) were tested by the lab in addition to the compounds requested in the original sample plan. The detection limits for the analyzed compounds are listed in Appendix B.

Several of the requested compounds were not analyzed by the ADEQ and the EPA contract laboratories. This was generally attributed to the lack of standards and/or testing methodologies available to analyze the soil samples for their detections.

The compounds which were not analyzed by the ADEQ contract laboratory for all sample sites included:

Bensulide	Pendimethalin	Terrazole
DCPA	Phosphamidon	Trifluralin
DEF	Profenofos	
Paraquat	Sulprofos	

The compounds which were not analyzed by the EPA contract laboratory included:

Acephate	Endosulfan I	Maneb
Aldicarb	Endosulfan II	Monocrotophos
Azinphos-Methyl	Endosulfan Sulfate	Parathion
Benzene	Endrin (Aldehyde)	Phorate
Carbofuran	EPN	Trichlorfon
Dicrotophos	Fenvalerate	2,4-DB
Endothall	Heptachlor Epoxide	

Benzene was not analyzed by the ADEQ contract laboratory in samples MSS 1 through MSS 8 because it was not requested.

The EPA contract laboratory which analyzed the split samples did not provide ADEQ with the necessary raw database to check for the validity of the lab results. The laboratory's quality assurance/quality control (QA/QC) practices were also not provided. Therefore, the results by the EPA contract laboratory as shown in Table 8 could not be verified for validity and were not used for statistical evaluation. Data provided appear as reported.

Results reported by the ADEQ contract laboratory which analyzed all of the Phase I samples, had evidence of inadequacies in the application of QA/QC practices. Some of the QA/QC problems encountered can be summarized as follows:

(1) The use of very reactive columns (degree of degradation was greater than 20%) in Method 8080 compromised the reported levels of organochlorine pesticides.

(2) The absence of matrix spikes and matrix spike duplicates, which are standard laboratory operating procedure, made the confirmation of reported results impossible.

(3) Significant differences between matrix spike recovery percentages and duplicates indicated laboratory analytical problems.

(4) Calibration problems with instrumentation were identified.

(5) The use of single-point instead of multiple-point calibration curves made the quantitation questionable.

(6) Significant differences between the original and split samples in terms of analytical results brought the reported results into question.

(7) Methods used were not always valid.

(8) Unacceptable response factors (RF) were observed in the calibration process.

(9) Calculations were not always confirmable.

Because of the above QA/QC problems, no verification would be made on the validity of laboratory data indicating non-detection of the following compounds:

Atrazine	Dicofol	Lindane
Azinphos-Methyl	Dieldrin	Maneb
Benzene (MSS 9 & 10)	Disulfoton	Methoxychlor
Bromacil	Endothall	Methyl Parathion
Captan	Endosulfan Sulfate	Monocrotophos
Carbaryl	Endrin	Phorate
Carbofuran	EPN	Profluralin
Chlordane	Fenvalerate	Pronamide
Cyanazine	Heptachlor	Propham
		Trichlorfon

Table 8. Pesticide Residues Agricultural Sites West Central Phoenix

(mg/kg)

	ADEQ CONTRACT LABORATORY											
	MSS 1	MSS 2	MSS 2D	MSS 3	MSS 4	MSS 5	MSS 5D	MSS 6	MSS 7	MSS 8	MSS 9	MSS 10
INSECTICIDES												
ALDICARB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AZINPHOS-METHYL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENZENE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND
CARBARYL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBOFURAN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLORDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDT	.008	.017	.051	.031	.023	.177	.390	.071	.15	.105	.049	.079
DDE	.013	.042	.150	.16	.094	.623	1.031	.242	.38	.021	.261	.318
DDD	.001	.004	ND	.007	.004	.063	.150	.026	.039	.015	.01	.012
DICROTOPHOS	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD
DIELDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIMETHOATE	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD
DISULFOTON	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN I	ND	ND	ND	.006	ND	ND	ND	ND	ND	ND	ND	ND
ENDOSULFAN II	ND	ND	ND	ND	ND	.005	.022	ND	ND	ND	ND	ND
ENDOSULFAN SULFATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN (ALDEHYDE)	ND	ND	ND	ND	ND	.02	.07	ND	.04	ND	ND	ND
ENDRIN	ND	.018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
EPN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

U.S. EPA CONTRACT LABORATORY			
MSS 2	MSS 4	MSS 5	MSS 7
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
ND	ND	.370	ND
NA	NA	NA	NA
ND	ND	ND	ND
.014	ND	.186	ND
.055	.094	1.292	.526
ND	ND	ND	ND
NA	NA	NA	NA
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
ND	ND	ND	ND
NA	NA	NA	NA

▦ Confirmed Non-Detected Findings

ND - Not Detected
NA - Not Analyzed
UTD - Unable to Determine

NOTE:Quantities indicated were reported by the lab but were not verified by ADEQ.

Table 8. Pesticide Residues Agricultural Sites - West Central Phoenix

(mg/kg)

	ADEQ CONTRACT LABORATORY												USEPA CONTRACT LABORATORY			
	MSS 1	MSS 2	MSS 2D	MSS 3	MSS 4	MSS 5	MSS 5D	MSS 6	MSS 7	MSS 8	MSS 9	MSS 10	MSS 2	MSS 4	MSS 5	MSS 7
INSECTICIDES (CONT'D)																
ETHION	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FENVALERATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
HEPTACHLOR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND	.011	ND	ND	ND	ND	ND	NA	NA	NA	NA
LINDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHOMYL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHOXYCHLOR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYL PARATHION	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MONOCROTOPHOS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
PARATHION	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
PHORATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
PHOSPHAMIDON	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND
PROFENOFOS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND
STROBANE	ND	ND	ND	2.7	ND	9.5	15.0	5.0	11.0	4.0	2.7	4.9	UTD	UTD	UTD	UTD
SULPROFOS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND
TOXAPHENE	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	ND	ND	ND	ND
TRICHLORFON	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA

▦ Confirmed Non-Detected Findings

ND - Not Detected
NA - Not Analyzed

UTD - Unable to Determine

Table 8. Pesticide Residues Agricultural Sites - West Central Phoenix

(mg/kg)

	ADEQ CONTRACT LABORATORY											
	MSS 1	MSS 2	MSS 2D	MSS 3	MSS 4	MSS 5	MSS 5D	MSS 6	MSS 7	MSS 8	MSS 9	MSS 10
HERBICIDES												
2, 4-D	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD
ARSENIC ACID	5.6	5.3	5.0	5.8	3.7	6.6	6.1	4.8	8.4	14.0	7.0	7.4
ATRAZINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BENSULIDE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BROMACIL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CYANAZINE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DCPA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DINOSEB	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD
DIURON	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOTHALL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MONURON	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NAPROPAMIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	.3
PARAQUAT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PENDIMETHALIN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PROFLURALIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PRONAMIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PROPHAM	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SILVEX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TEBUTHIURON	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRIFLURALIN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

USEPA CONTRACT LABORATORY			
MSS 2	MSS 4	MSS 5	MSS 7
.032/ .014	.013/ .011	.002/ .009	.014
6.3	2.5	8.8	8.7
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
.002	.006/ .008	ND	.001
ND	ND	ND	ND
NA	NA	NA	NA
ND	.480	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
1.9	ND	ND	ND
UTD	UTD	UTD	UTD

▦ Confirmed Non-Detected Findings

ND - Not Detected

NA - Not Analyzed
UTD - Unable to Determine

Table 8. Pesticide Residues Agricultural Sites - West Central Phoenix

(mg/kg)

	ADEQ CONTRACT LABORATORY												USEPA CONTRACT LABORATORY			
	MSS 1	MSS 2	MSS 2D	MSS 3	MSS 4	MSS 5	MSS 5D	MSS 6	MSS 7	MSS 8	MSS 9	MSS 10	MSS 2	MSS 4	MSS 5	MSS 7
OTHER																
CAPTAN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	UTD	UTD	UTD	UTD
DEF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND
DICOFOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	UTD	ND	ND	ND	ND
MANEB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
TERRAZOLE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	UTD	UTD	UTD	UTD
ACEPHATE*	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	NA	NA	NA	NA
2,4-DB*	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	UTD	NA	NA	NA	NA

* Not Originally in Sample Plan Analyzed for Detection Later

▦ Confirmed Non-Detected Findings

ND - Not Detected

NA - Not Analyzed

UTD - Unable to Determine

In addition, the non-detection reported for endosulfan I, endosulfan II, endrin (aldehyde), endrin, and heptachlor epoxide for all sample sites except MSS 2, MSS 3, MSS 5 and MSS 5D (duplicate sample) could not be verified. These last four sample sites had valid positive detections though the quantitations could not be verified because of the above QA/QC problems.

Of the pesticides analyzed by the ADEQ contract laboratory, non-detection was verified for nine compounds. These chemicals were:

Aldicarb	Methomyl	Tebuthiuron
Diuron	Parathion	Monuron
Ethion	Silvex	Napropamide

While the non-detection of napropamide in MSS 1 through MSS 9 was confirmed, it was not possible to confirm the reported concentration of napropamide associated with MSS 10 (0.3 mg/kg).

Due to the extremely low matrix spike recovery percent, the ADEQ contract laboratory was not able to analyze for acephate, 2,4-D acid, 2,4-D butyric acid, dicrotophos, dimethoate or dinoseb in collected soil samples.

The reported concentrations of arsenic, DDT, DDD, DDE and toxaphene could not be verified due to one or more of the previously mentioned QA/QC problems; nevertheless, their presence in various selected agricultural sites was confirmed.

The reported concentration of arsenic was not confirmed, therefore, it is not known if the detected arsenic in the selected agricultural sites was indigenous in nature or resulted from the application of arsenic acid and cacodylic acid defoliants. However, the levels reported were within the range which could be considered natural (Dragon, 1988).

The use of a reactive column in Method 8080 by the ADEQ contract laboratory was responsible for the uncertainty in the reported concentration of DDT in all the selected agricultural sites in west central Phoenix.

Because of the use of this reactive column, it was not clear how much of the DDD and DDE detected in the selected agricultural sites was associated with the degradation of DDT under natural conditions. During its passage through the reactive column, a significant portion of DDT would have been degraded to DDD and DDE, thus contributing to a rather murky picture of the qualitative and quantitative aspects of DDT, DDD and DDE as reported by the contract laboratory.

Toxaphene (reported as strobane by the contract laboratory) was also detected during the Phase I analysis. Although its presence in the soil samples was confirmed, all the previously mentioned QA/QC problems make the reported concentration of toxaphene unreliable.

Due to the aforementioned laboratory uncertainties, the results from the Phase I sampling from either the ADEQ or EPA contract laboratories were not analyzed statistically. However, it can be concluded that DDT and its metabolites (DDD, DDE) and toxaphene appeared to occur consistently at the agricultural sites, and their presence is likely due to agricultural uses. Furthermore, residues of other chemicals including endosulfan I, endosulfan II, endrin (aldehyde), endrin, and heptachlor epoxide occur more sporadically, probably due to less widespread agricultural uses.

2. Phase I Resampling

The analytical results from the Phase I resampling effort are presented in Table 9. The statistical results (Analysis of Variance ANOVA) corresponding to the Phase I resampling of selected agricultural sites in west central Phoenix are presented in Table 10. The detection limits for the analyzed compounds are listed in Appendix B.

The results indicated that the reported concentration of arsenic, total DDT compounds and toxaphene at sites 5 and 10 were not affected by the method of sampling. Therefore, whether the analyzed sample was the composite of 36 sub-samples within the grid or a discrete sample outside or inside the grid, the analytical result was statistically similar.

The sampling procedure using composites, therefore, provided a representative value for the site.

The data shown in Table 10 also reflect that the concentration of arsenic in sites 5 and 10 are statistically similar; whereas the difference in the total DDT compounds and toxaphene between these two sites was significant at p=0.01. Therefore, the concentration of total DDT compounds and toxaphene at site 5 was significantly higher than that of site 10. The reason for this is unknown.

A sample composed only of a composite of 36 sub-samples was taken at site 2 (Alhambra School); therefore, it was not included in the statistical analysis presented in Table 10. However, it seems qualitatively that the concentration of arsenic, total DDT compounds and toxaphene were much lower than those associated with sites 5 and 10, as would be expected.

Given that the concentration of arsenic detected in sites 2, 5 and 10 was still within the range of concentration (1.0 to 40 mg/kg) normally found in natural soil (Dragon, 1988), it cannot be concluded that the higher arsenic concentration (up to 32 mg/kg) associated with these sites compared to the control (MSS BDA) is due to the application of arsenic-containing chemicals to defoliate cotton. Nevertheless, the concentration of arsenic detected in these sites is much lower than the Department's published draft Health Based Guidance Level (HBGL) of 1,000 mg/kg (ADEQ, 1990).

The presence of DDT and its degradation compounds (DDD and DDE) and toxaphene in sites 2, 5 and 10 and their absence in site BDA (control) indicate that these chemicals had been used on these sites in the past. However, none of these sites contained a concentration of total DDT compounds higher than the draft HBGL (2.0 mg/kg). The concentration of toxaphene in site 5 was higher than the draft HBGL (0.6 mg/kg) while the toxaphene concentrations observed in sites 2 and 10 were below the draft HBGL.

Table 9. Pesticide Residues Agricultural Resampling Sites
West Central Phoenix

(Residues in mg/kg)

ANALYTE	MSS 5 SAMPLE 1	MSS 5 SAMPLE 2	MSS 5 SAMPLE 3	MSS 5 SAMPLE 4	MSS 5 SAMPLE 5	MSS 5 SAMPLE 6	MSS 5 SAMPLE 7	MSS 10 SAMPLE 1	MSS 10 SAMPLE 2	MSS 10 SAMPLE 3	MSS 10 SAMPLE 4	MSS 2 SAMPLE 1	MSS BDA 1*
ASENIC ACID as ARSENIC	26	24	25	23	20	22	24	25	29	25	32	11	3.0
DDD	.12	.09	.10	.10	.08	.10	.12	.03	0.02	.01	.02	ND	ND
DDE	.72	.75	.88	1.05	.65	.88	.88	.27	.20	.20	.27	0.08	ND
DDT	.13	.14	.14	.16	.10	.14	.16	.04	.02	.02	.03	0.02	ND
DIELDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDOLSUFAN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ENDRIN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LINDANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
STROBANE/ TOXOPHENE TOTAL	1.04	0.7	0.9	0.9	0.7	0.9	1.0	0.24	0.14	0.14	0.22	0.16	ND
TEXTURE	98.2	94.0	96.8	97.3	93.1	98.9	98.6	92.2	92.4	92.2	90.8	57.2	42.9
TOC[1]	6090	6680	7350	8660	6810	7990	6850	4810	7750	6390	8690	13,200	8990

LEGEND

ND = NOT DETECTED
* = CONTROL SITE

NOTES

MSS 5 -	Sample 1 =	Composite sample of 36 subsamples
	Sample 2 =	Inside the grid sample
	Sample 3 =	Inside the grid sample
	Sample 4 =	Inside the grid sample
	Sample 5 =	Outside the grid sample
	Sample 6 =	Outside the grid sample
	Sample 7 =	Outside the grid sample
MSS 10 -	Sample 1 =	Composite sample
	Sample 2 =	Inside the grid sample
	Sample 3 =	Inside the grid sample
	Sample 4 =	Inside the grid sample

Table 10. Analysis of Variance (ANOVA) on Arsenic, Total DDT Compounds and Toxaphene Detected in the Second Phase of Sampling

Source	Arsenic F-value		df	Total DDT# F-value		df	Toxaphene F-value		df
Site	2.0	ns	1	104.1	**	1	175.0	**	1
Method	0.4	ns	6	1.6	ns	6	2.9	ns	6

\# DDT + DDD + DDE
** Significant at p=0.01
* Significant at p=0.05
ns Non-significant at p>0.05

The following chemicals, other than those already discussed, were analyzed by Method 8080, Method 8140, Method 8150 and Modified Method 632 during the Phase I resampling effort but were not detected in the soil samples:

2,4-D
2,4-DB
2,4-5-T
Aldrin
Alpha-BHC
Aroclor 1016
Aroclor 1221
Aroclor 1232
Aroclor 1242
Aroclor 1248
Aroclor 1254
Aroclor 1260
Azinphos-Methyl
Beta-BHC
Bromacil
Carbaryl
Carbofuran
Chlordane
Chlorpropham
Delta-BHC
Demeton
Diazinon
Dicamba
Dieldrin
Dinoseb
Disulfoton
Diuron
Endosulfan I
Endosulfan II
Endosulfan Sulfate
Endrin
Endrin (Aldehyde)
Endrin (Ketone)
Ethion
Ethyl Parathion
Gamma-BHC (Lindane)
Heptachlor
Heptachlor Epoxide
Linuron
Malathion
Methomyl
Methoxychlor
Methyl Parathion
Neburon
Oxamyl
Propham
Propuxor
Silvex

3. Conclusions

Qualitatively, the results of the resampling generally agreed with those of the Phase I. In both phases, arsenic, DDT and toxaphene were detected in the selected agricultural sites of west central Phoenix.

There was little doubt that the DDT, DDD, DDE and toxaphene detected in the selected agricultural sites were associated with agricultural activities.

The arsenic detected in various sites of this investigation was in the range which is considered naturally occurring (4-40 mg/kg).

B. Phase II Results and Discussion

1. General Results

The laboratory results for Phase II from Analytical Technologies were reported for the 13 analytes as requested. Samples were also tested for lead residues for selected samples in response to a request from ADHS after sampling. Due to the fact that the methods (8080, 8140, 8150, and Modified 632) used in the analysis are designed to discriminate among classes of compounds, more compounds than the 13 specifically requested were analyzed. Data was actually provided for a total of 53 compounds. The compounds and their detection limits are listed in Appendix B.

Any analyte detected in at least one of the Phase II samples is listed in Tables 11 and 12. In the tables, the pesticides are listed in the left-hand column; the sampling sites are identified along the top row. The lead analysis results are in Table 13. A map showing the location of the sampling sites is illustrated in Figure 10 .

Table 11 - Schools/Parks Sample Sites, shows that the compounds detected most frequently were DDT, DDD, and DDE. Concentrations detected ranged from 0.01 to 1.1 mg/kg. (total DDT, DDD and DDE combined). Chlordane, toxaphene, and 2,4-D appeared sporadically throughout the samples; not enough to suggest a pattern.

In Table 12 - Residential Sample Sites, the compounds most commonly detected were DDT, DDD, DDE, chlordane, and dieldrin. Residues of these compounds were found in samples from lawns, gardens, play areas, and near the structures. Chlordane was detected within a wide range of concentration: 0.15 - 290.0 mg/kg. Dieldrin was detected within the range between 0.04 -47 mg/kg. The range of concentration detected for total DDT, DDD, and DDE was between 0.01 - 6.0 mg/kg. The toxaphene concentration was 1.0 mg/kg in three of the samples; heptachlor was detected at 4.2 mg/kg in one sample. Compounds that were detected sporadically were endosulfan I, endrin, heptachlor, heptachlor expoxide, toxaphene, diazinon, and 2,4-D.

Arsenic was detected in all of the samples. It ranged between 11 mg/kg and 35 mg/kg. Ziram was detected in only one sample.

Table 11. West Central Phoenix Pesticide Residues Schools/Parks Sample Sites (mg/kg)

PESTICIDE	(9) SUEÑO PARK					(10) W.R. SULLIVAN S.		(11) JOHN F. LONG S.			(12) MARIVUE PARK			(13) PALM LANE S.			(14) ST. VINCENT DE PAUL				(15) ANDALUCIA S.			MEYER S. (CONTROL)			DRAFT HBGL
	F1	F2	P1	P2	I	F1	F2	F1	F2	P1	F1	F2	P1	F1	F1d	F2	F1	F2	P1	P2	F1	F1d	F2	F1	F2	P1	SOIL
Aldrin	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
Arsenic	19.8	23.6	5.4	13.4	14.0	22.6	24.0	23.4	23.1	8.8	29.0	21.0	6.1	35.0	29.0	24.0	20.0	25.0	5.6	24.0	23.0	19.0	18.0	18.0	17.0	18.0	1,000
Chlordane	---	---	.24	.07	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.4
DDD	---	---	---	.01	---	---	---	---	---	---	.01	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Total 2.0
DDE	1.1	.9	---	.09	.03	---	.2	.07	.07	---	.05	.03	---	.01	.01	.07	---	---	---	---	.07	.08	.32	---	---	---	
DDT	---	---	---	.01	.01	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.02	---	---	---	
Diazinon	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	12.0
Dieldrin	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.02
Endosulfan I	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7.0
Endrin	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	4.0
Heptachlor	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.16
Heptachlor Epoxide	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.08
Toxaphene	1.0	1.0	---	.2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.1	---	---	---	.6
Ziram	---	---	---	---	---	---	.35	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	NA
2,4-D	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.05	---	---	---	---	---	---	---	1400.0

F = BALL FIELD P = PLAY AREA I = IRRIGATION DITCH F1d = BALL FIELD DUPLICATE SAMPLE

Table 12. West Central Phoenix Pesticide Residues Residential Sample Sites (mg/kg)

PESTICIDE	(1) 4200 N. 49th AVE.					(2) 3700 W.VERDE LN.		(3) 1100 N. 29 DRIVE				(4) 5300 W. CORONADO			(5) 4400 W. WELDON LN.			(6) 6300 W. SELLS DRIVE				(7) 3100 N 52ND PKWY		(8) 6200 W MONTERRY WY		1000 E. FAIRMONT (CONTROL)			DRAFT HBGL
	L	S	G	P1	P2	L	S	L	S	P1	P2	L	S	P1	L	Ld	S	L	Ld	S	G	L	S	L	S	L	S	G	SOIL
Aldrin	---	9.7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.04
Arsenic	22.0	27.0	12.0	23.0	15.0	21.0	20.0	16.0	15.0	17.0	29.0	11.0	17.0	13.0	15.0	13.0	11.0	19.0	26.0	27.0	24.0	18.0	25.0	22	26	16.0	24.0	21.0	1,000
Chlordane	1.0	86.0	7.0	8.0	4.0	.37	8.0	2.0	19.0	2.0	.46	.33	.25	.15	4.0	1.6	290.0	---	---	---	---	2.0	7.2	.2	9.0	---	1.4	2.0	.4
DDD	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.3	.3	.5	.2	---	---	.11	---	---	---	---	TOTAL
DDE	---	---	.5	---	---	.05	6.0	---	1.0	---	---	.05	.04	.05	.2	.2	---	1.6	1.8	2.7	1.5	.2	.7	1.2	---	.17	.4	.4	2.0
DDT	---	5.0	.8	---	.3	---	6.0	---	1.0	---	---	---	.01	.01	---	---	---	.2	.3	.6	.2	.3	1.1	.15	---	---	.1	.1	
Diazinon	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.29	---	---	---	---	---	12.0
Dieldrin	.4	30.0	1.5	2.0	---	.28	3.0	2.2	23.0	1.9	.39	---	---	---	.7	.6	28.0	---	---	---	---	14.0	47.0	.25	6.0	.04	.2	.2	.02
Endosulfan I	---	---	---	---	.7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7.0
Endrin	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.2	1.2	---	---	---	---	---	4.0
Heptachlor	---	4.2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.16
Heptachlor Epoxide	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.1	---	.03	.8	---	---	---	.08
Toxaphene	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1.0	1.0	1.0	---	---	---	---	---	---	---	---	.6
Ziram	---	---	---	---	---	---	---	---	---	---	.25	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	NA
2,4-D	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.13	.07	---	---	---	1400.0

L = Lawn S = Structure (foundation) G = Garden P1 = Play Area (0-6") P2 = Play Area (6-12") Ld = Lawn Duplicate Sample

Table 13. Lead Analysis for Sample Sites*

Sample Sites	Location	Lead Detection (mg/kg)
4200 block of N. 49th Ave.	Lawn	81.0
3700 block of W. Verde Lane	Yard	44.0
1100 block of N. 29th Dr.	Lawn	28.0
5300 block of W. Coronado St.	Yard	15.0
4400 block of W. Weldon Ln.	Yard	28.0
6300 block of W. Sells Dr.	Yard	17.0
3100 block of N. 52nd Pkwy.	Lawn	40.0
6200 block of W. Monterrey Way	Lawn	30.0
1000 block of East Fairmont	Yard	17.0
Sueño Park	Field	20.0
W.R. Sullivan School	Field	18.0
John F. Long School	Field	15.0
Marivue Park	Field	13.0
Palm Lane Park	Field	12.0
St. Vincent de Paul School	Field	17.0
Andalucia School	Field	19.0
Meyer School	Field	14.0

*ADEQ Draft HBGL mg/kg

Samples were also analyzed for the following compounds; none were detected:

2-4 DB	Bromacil	Endrin (Ketone)
2,4,5-T	Carbaryl	Ethyl Parathion
Alpha-BHC	Carbofuran	Methyl Parathion
Aroclor 1016	Chlorpropham	Ethion
Aroclor 1221	Delta-BHC	Gamma-BHC (Lindane)
Aroclor 1232	Demoton	Linuron
Aroclor 1242	Dinoseb	Malathion
Aroclor 1248	Disulfoton	Methomyl
Aroclor 1254	Diuron	Methoxychlor
Aroclor 1260	Endosulfan II	Neburon
Azinphos-Methyl	Endosulfan Sulfate	Oxamyl
Baygon (Propuxor)	Endrin (Aldehyde)	Propham
Beta-BHC		

2. Quality of Data

In Phase II, in addition to the normal quality assurance/ quality control (QA/QC) protocol established by the contract laboratory, a split from one of the samples was spiked with various pesticides and the amount of each was subsequently quantified. The analytical results shown in Table 14 clearly indicate that, with the exception of Captan, the percent recoveries for all spiked pesticides fall within acceptable range. The rather low percent recovery for Captan (43 percent) is not surprising given the fact that its dissipation half-life is only 2.5 - 6.0 days (Captan Task Force, 1990). The Relative Percent Difference (RPD) of each spiked pesticide also falls within an acceptable range. The review of QA/QC data provided by the laboratory indicates that the data is of sufficient quality for statistical evaluation.

3. Statistical Analysis

The Phase II database was transformed logarithmically and the hypothesis that the parameters of both residential and public sectors are lognormally distributed was tested using the W-Test (Shapiro and Wilk, 1965). The Kolmogorov-Smirnov test (KS) for goodness-of-fit (Sokal and Rohlf, 1981) and the related Lilliefors Test (Lilliefors, 1967 and Lilliefors, 1979) were not used because the number of variates (n) in each of the parameters was less than 50. The hypotheses tested were:

H_O: The population is lognormally distributed.
vs.
H_A: The population is not lognormally distributed.

Table 14. Percent Recovery of Various Chemicals on a Selected Soil Sample

Chemical	Rep I*	Rep II	Mean	RPD@
			%	
Dithiocarbamates	92	-	92	-
As	76	80	78	5.0
Pb	98	104	101	5.9
Bromacil	98	98	98	0.0
Neburon	98	99	99	1.0
Linuron	104	104	104	0.0
Carbaryl	97	103	100	6.0
Baygon	95	95	95	0.0
Gamma BHC	94	109	102	14.7
Heptachlor	91	103	97	12.4
Aldrin	94	109	102	14.7
Dieldrin	88	106	97	18.6
Endrin	94	109	102	14.7
DDT	100	106	103	5.8
Heptachlor epoxide	90	103	97	13.4
Captan	43	43	43	0.0
Chlordane	94	88	91	6.6
Toxaphene	127	115	121	9.9
Diazinon	118	92	105	24.8
Disulfton	110	93	102	16.7
Ethyl Parathion	89	74	82	18.3
Acephate	91	73	82	22.0
DDVP	120	110	115	8.7
2,4-D	71	65	68	8.8
Silvex	64	70	67	9.0

@RPD = Relative Percent Difference:

$$RPD = \frac{(\text{Difference of Rep I and Rep II})}{(\text{Mean of Rep I and Rep II})} \times 100\ \%$$

*REP = Lab Duplicate Sample

When H_0 is not rejected, the database is regarded to be lognormally distributed. The W value in the W-test was computed as described by Shapiro and Wilk (1965). The null hypothesis H_0 is rejected at α=0.05 (95% confidence interval) when the evaluated W is less than the quantile given in the standardized table developed by Shapiro and Wilk (1965).

The results of the W-Test for each parameter for residential and public sites are shown in Table 15. Since the calculated W values exceed the table $W_{0.05}$ figures, the results indicate that at α=0.05, the lognormal distribution is a reasonable approximation of the true unknown distribution for arsenic, chlordane, total DDT and dieldrin in both the residential and public sectors. Therefore, the statistical analysis should be conducted on the logarithmically transformed data. At the same time, it was found that the estimator, μ (to estimate μ - the population mean) derived by Gilbert's equation (1987) based on the logarithmically transformed data is highly correlated with the corresponding arithmetic (x) mean associated with the original data (Fig. 11).

An analysis of variance (ANOVA) was conducted on the concentration of arsenic, chlordane, total DDT compounds and dieldrin for residential and public sectors using a Systat software package. The residential and public locations sampled in this study are referred to as sites whereas locations within sites such as the lawn, foundation, play area, garden and athletic field are designated as areas in the statistical analysis. The estimator of the population mean (μ) and confidence intervals ($CI_{0.95}$) of each parameter were determined (Table 16) using equations derived by Gilbert (1987) and Land (1971, 1975), respectively.

4. Arsenic

The ANOVA results shown in Table 17 indicate that among the residential sites, the arsenic concentrations are significantly different from each other at p=0.05 (F=4.07); however, among the lawn, foundation, garden and play area samples within each site, the differences in the total arsenic concentration are not significant (F= 1.94). Among the public sites, the arsenic concentrations are not significantly different from each other at p>0.05 (F=0.4); whereas among the two athletic fields and play areas (0-15 cm), the arsenic concentrations are significantly different at p=0.01 (F=16.73).

The significantly lower arsenic concentrations in samples from the play area fields compared to the athletic field samples are probably due to the fact that sand, which had lesser amounts of arsenic than the soils at the fields, was imported for the play areas; thus causing a dilution effect.

Table 15. The W-Test of Various Parameters in both Residential and Public Sites in West Central Phoenix

	Residential			Public		
Parameter	n[#]	W	$W_{0.05}$	n	W	$W_{0.05}$
Arsenic	26	0.99	0.92	24	0.88	0.92
ln Arsenic	26	0.99	0.92	24	0.93	0.92
Chlordane	22	0.35	0.91	-	-	-
ln Chlordane	22	0.94	0.91	-	-	-
DDD+DDE+DDT	19	0.62	0.90	13	0.64	0.84
ln DDD+DDE+DDT	19	0.94	0.90	13	0.94	0.84
Dieldrin	19	0.64	0.90	-	-	-
ln Dieldrin	19	0.95	0.90	-	-	-

[#] number of sites

Figure 11. Relationship Between the Estimator and the Arithmetic Mean

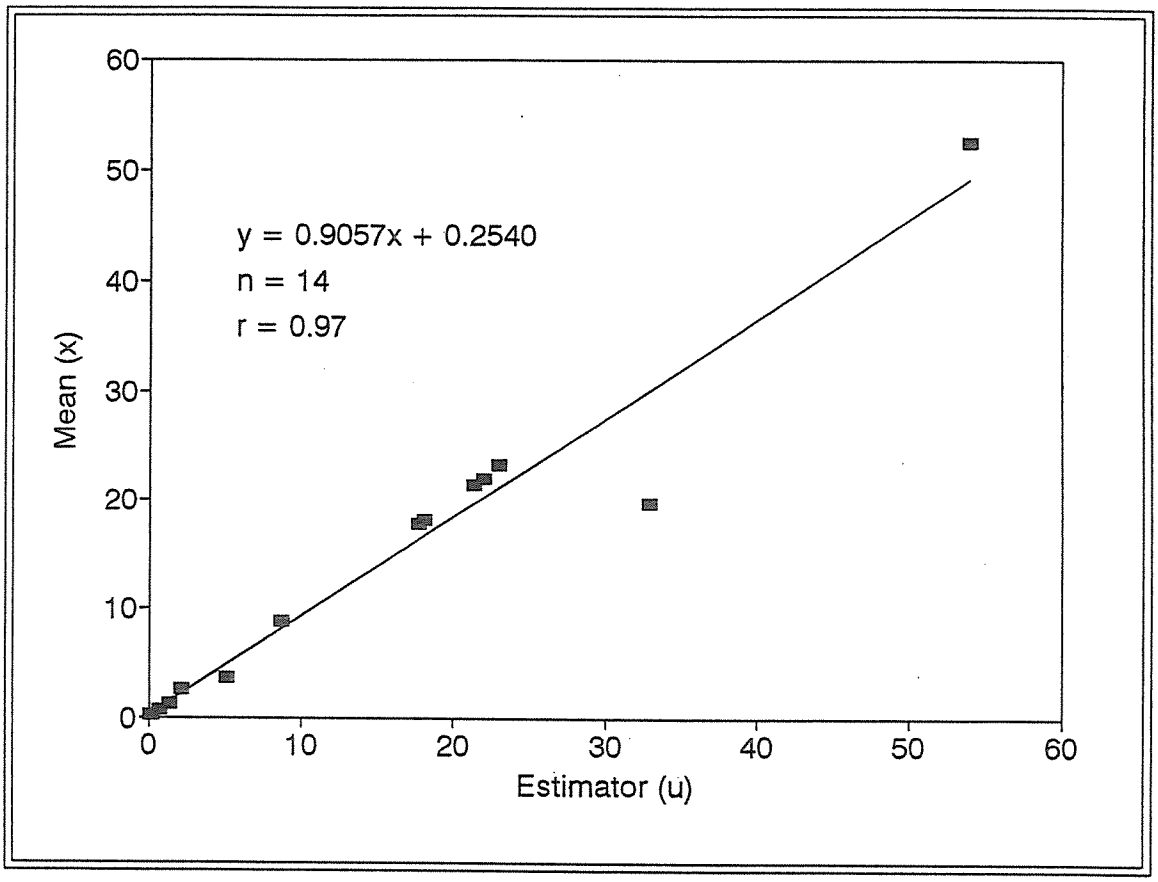


Table 16. Mean (μ), Coefficient of Variation (CV) and Confidence Limit (CI) of Arsenic, Chlordane, Dieldrin and Total DDT[#]

Chemical	Area	n	CV(%)[@]	μ^*	$CI_{0.95}$[$]
					mg/kg
Residential					
Arsenic	Lawn	9	22.7	18.1	15.7-21.5
	Foundation	9	27.4	21.4	18.0-27.2
	Play area (0-15cm)	3	28.5	17.7	12.4-40.1
Chlordane	Lawn	7	82.5	1.3	0.7-7.5
	Foundation	8	190.1	54.0	19.9-39130
Total DDT	Lawn	7	128.9	0.7	0.3-22.7
	Foundation	7	113.9	5.1	2.0-722.7
Dieldrin	Lawn	7	200.0	2.1	0.8-367.4
	Foundation	7	87.8	32.9	12.2-10439
Public					
Arsenic	Athletic 1	8	20.9	23.0	20.5-26.9
	Athletic 2	8	13.6	22.0	20.1-24.4
	Play area (0-15 cm)	5	60.7	8.7	5.6-18.7
Total DDT	Athletic 1	5	179.0	.2	0.1-258.6
	Athletic 2	6	87.3	0.1	0.1-0.6

[@] Based on the original data.

* An estimator computed by the equation of Gilbert (1987) to estimate the μ of the population.

[$] Computed by the equations derived by Land (1971, 1975).

[#] Total DDT=DDD+DDE+DDT

Table 17. Analysis of Variance (ANOVA) on Various Chemicals Detected at both Residential and Public Sites of West Central Phoenix (0-6")

Source	F-value				
Residential					
	Arsenic	Chlordane	Dieldrin	Total	DDT[#]
Site	4.07 *	4.34 *	13.8 **	1.81	ns
Area	1.94 ns	6.88 *	10.6 **	1.85	ns
Public					
Site	0.40 ns	-	-	5.10	ns
Area	16.73 **	-	-	0.97	ns

\# DDT+DDD+DDE

** Significant at p=0.01

* Significant at p=0.05

ns Non-significant at p>0.05

The composite data of both residential and public sites indicated that arsenic concentration is not influenced by sampling depth (Table 18).

The arsenic concentrations in samples from residential and public sites are well within the typical range of 1.0-40 mg/kg normally found in native soil (Dragon, 1988). Therefore, the arsenic at these sites might not be the result of cacodylic acid or arsenic acid applied during previous agricultural activities. At the same time, the arsenic concentration found in samples of both residential and public sites was below the draft HBGL of 1,000 mg/kg (ADEQ, 1990).

5. Chlordane

The data shown in Table 17 indicate that the difference in the chlordane concentrations detected among residential sites is significant at p=0.01 (F=4.34). This difference is likely attributable to differences in treatment history and soil types among sites.

The chlordane concentrations detected were also significantly different among lawn, structure, garden and play areas (0-15 cm) at p=0.01. Structural samples were consistently higher in chlordane residue concentrations than other areas. This is due to the prevalent use of chlordane as a treatment for termites and other forms of pest control.

The ANOVA results based on the composite data of residential and public sites showed that the chlordane concentrations detected at 0-15 cm are significantly higher than those at 15-30 cm at p=0.05 (Table 18). This is not surprising since most chlordane applications are made on or near the surface and chlordane is very immobile.

Given that technical chlordane normally contains less than 25% heptachlor as impurity (Verschueren, 1983) and that chlordane and heptachlor have similar dissipation rates as reported by Edwards (1966) and Kearney et al. (1965), one would also expect heptachlor or heptachlor epoxide to be detected in the foundation soil samples from residential sites 3 and 5 where the chlordane concentrations were extremely high. However, heptachlor and heptachlor epoxide were not detected in these samples. This might be due to an abnormal composition of the technical chlordane used at these two sites. Unlike sites 3 and 5, heptachlor and/or heptachlor epoxide were detected along with chlordane in residential sites 1 and 8, where the chlordane concentrations were moderately high (86 mg/kg and 9 mg/kg, respectively). It is possible that the composition of technical chlordane at sites 1 and 8 are more typical.

Table 18. Analysis of Variance (ANOVA) on the Composite Data of Chlordane and Arsenic at Two Depths of Residential and Public Sites

Source	F-value	df	F-value	df
	Chlordane		Arsenic	
Site	90.2 *	2	1.2 ns	3
Depth	24.3 *	1	2.4 ns	1

* Significant at p=0.05

ns Non-significant at p>0.05

With the exception of site 6, chlordane residuals were detected in all samples from residential sites taken within 30 cm from the house foundation and within a depth of 15 cm. Site 6 was probably not treated with chlordane in the last 10-20 years although it is not clear when it was last treated for structural termite control.

The assumption that chlordane was largely used around the house foundation for pest control rather than for routine backyard gardening is supported by the results of an ANOVA conducted on the database (Table 19). The results shown in Table 19 indicate that the chlordane concentrations associated with the foundation are significantly higher than those of the lawn at p=0.01.

With the exception of the lawn samples from sites 8, 12 and 2, the chlordane concentration detected in residential soil samples (.46-290 mg/kg) is higher than the draft HBGL (0.4 mg/kg).

Chlordane was only detected in the play areas (0 - 15 cm and 15 - 30 cm) of site 9 among the public sites. The chlordane concentration detected in these samples was below the draft HBGL.

It is concluded that the chlordane residues detected in samples from the home foundations result from residential pest control. This conclusion is supported by the fact that chlordane was not detected in the Phase I (agricultural) sampling, nor was it detected in 24 of the 26 school/park sample sites during the Phase II sampling.

6. Dieldrin

The ANOVA results in Table 17 indicate that the differences in the dieldrin concentrations in soil among residential sites are significant at p=0.01. The differences in the dieldrin concentrations among samples collected from areas within sites were also significant at p=0.01. This indicates a significant variation in the distribution of dieldrin among the sample sites and areas within each sample site (lawn, structure, etc.).

The significantly higher dieldrin concentration in samples taken from the house foundation compared to that of the lawn samples as reflected by the ANOVA results (Table 19) implies that dieldrin might also have been used along with chlordane in structural pest control at all the residential sites with the exception of sites 4 and 6. At the play areas of residential sites 1 and 2, the dieldrin concentration of the surface sample (0-15 cm) was higher than that of the subsurface sample (15-30 cm). Given the extremely high soil adsorption value of dieldrin (K_{oc}=35600) shown in Table 20, surface applied dieldrin would have an extremely low probability of leaching into the subsurface soil.

Table 19. Analysis of Variance (ANOVA) on Chlordane and Dieldrin from Lawn and Foundation of Residential Sites

Source	F-value	df	F-value	df
	Chlordane		Dieldrin	
Sites	2.7 ns	7	10.4 **	6
Area	6.5 **	1	40.3 **	1

** Significant at p=0.01

ns Non-significant at p>0.05

Table 20. Dissipation Rate, Vapor Pressure, and K_{oc} of Chlordane, Heptachlor, Dieldrin, Endrin, Toxaphene, 2,4-D and DDT

Chemical	Vapor Pressure mmHg (25°C)	Dissipation Rate	K_{oc}
Chlordane	1.0×10^{-5} [a]	3-5 yrs (75-100%) [bc]	3990 [e]
Heptachlor	3.0×10^{-4} [a]	2-5 yrs (75-100%) [bc]	30000 [f]
Dieldrin	1.8×10^{-7} [d]	3-25 yrs (75-100%) [bc]	35600 [f]
DDT	1.9×10^{-7} [d]	4-30 yrs (75-100%) [bc]	240000 [g]
Endrin	2.0×10^{-7} [a]	6 yrs (50%) [o]	34000 [f]
Toxaphene	9.9×10^{-7} [k]	69 days (50%) [j]	98600 [h]
2,4-D Acid	1.4×10^{-7} [i]	<10 days (50%) [lmn]	30 [i]

[a] Worthing (1979)
[b] Edwards (1966)
[c] Kearney et al. (1965)
[d] Verschueren (1983)
[e] The K_{oc} was obtained using the equation and K_{oc} data reported by Rao and Davidson (1982).
[f] Kenaga (1980)
[g] Thomas (1982).
[h] McDowell et al. (1981)
[i] 2,4-D Task Force (1990)
[j] Seiber et al. (1979)
[k] Leonard et al. (1976)
[l] Radosevich and Winterlin (1977)
[m] Stewart and Gual (1977)
[n] Wilson and Cheng (1976)
[o] Nash et al. (1983)

The absence of dieldrin/chlordane/heptachlor in the soil sample from the house foundation at site 6 might be due to one or more of the following reasons:

a. Dieldrin/chlordane/heptachlor had not been used at site 6. Given the very immobile characteristics of these chemicals as reflected by their extremely high soil adsorption coefficient (K_{oc}) and their rather low dissipation rate constant and vapor pressure (Table 20), they would likely be detected in the foundation sample (0-15 cm) of site 6 if they had been applied consistent with the practice employed by the structural pest control industry in Phoenix.

b. Dieldrin/chlordane/heptachlor had been used in structural pest control but was applied on the surface instead of subsurface; therefore, most of this surface applied dieldrin/chlordane/heptachlor was lost through volatilization within a very short period of time.

This hypothesis regarding the loss of surface-applied dieldrin/chlordane is supported by the results of the studies conducted by Glotfelty et al. (1984) and Taylor et al. (1977).

All dieldrin concentrations detected in samples from public and residential sites were higher than the draft HBGL (.02 mg/kg). The coefficient of variation (CV) of the dieldrin concentration is lower than that corresponding to the chlordane concentration in the foundation samples of the residential sites (87.8% vs. 190.0%). This suggests that dieldrin was applied in a more uniform or consistent manner than chlordane. No dieldrin was detected in the samples from public sites.

As with chlordane, dieldrin in the residential sites is most likely the result of structural pest control. The hypothesis that the detected dieldrin was a carry-over from agricultural use is not supported by these data. Dieldrin was not found during the Phase I sampling, nor was it detected in any of the school/parks sample sites.

7. Total DDT

DDT and its degradation products DDE and DDD (total DDT) were detected at every residential site. The ANOVA results shown in Table 17 indicate that the difference in total DDT concentration in soil among residential sites and areas is not significant. The fact that total DDT concentration seems to be uniformly distributed among samples is not surprising, given the facts that:

a. all the sampled residential sites were previously associated with agricultural production and were subject to the routine use of DDT compounds for pest management during the time the land was used for agricultural production.

b. DDT, DDD and DDE have an extremely high K_{oc} value of 240,000 (Thomas, 1982) and exceedingly long residual effect (Chisholm et al., 1950; Lichtenstein et al., 1971 and Cooke and Stringer, 1982, and Table 20).

The impact of sampling depth on the concentration of total DDT could not be determined due to insufficient data. The total DDT concentrations in soil samples from the garden, play area and lawn of various residential sites (except site 6) are below the proposed HBGL (2.0 mg/kg). The foundation samples of sites 1, 2, and 6 demonstrate a higher total DDT concentration than the proposed HBGL.

Among the public sites, the total DDT concentrations in soils are not significantly different from each other; at the same time, the two athletic fields contain statistically similar total DDT concentrations (Table 17).

DDT and its degradation products were not detected in the two athletic fields and play areas of the control site and site 14.

None of the samples from the public sites contained total DDT at a concentration higher than the proposed HBGL.

Residues of DDT and its degradation products of DDD and DDE are hypothesized to result from both agricultural and structural applications. This conclusion is supported by the consistent detection of DDT, DDD, and DDE in the Phase I sampling. Furthermore, the higher concentrations of total DDT in some of the residential sample sites could be attributed to supplemental use for residential (structural) pest control.

8. Heptachlor/Heptachlor Epoxide

Heptachlor and heptachlor epoxide were detected only in soil samples of sites 1, 7 and 8 among the residential sites. Heptachlor epoxide likely resulted from the degradation of heptachlor which existed either as an impurity in technical grade chlordane or was simply mixed with chlordane for direct application.

The residues from these compounds probably result from structural pest control use. The detection of heptachlor in the structural sample of site 1 (4.2 mg/kg) exceeds the draft HBGL of 0.16 mg/kg. Of the three detections for heptachlor epoxide, two (0.1 and 0.8 mg/kg) exceed the draft HBGL of 0.08 mg/kg. Neither heptachlor nor heptachlor epoxide was detected in any of the public sites or in the Phase I agricultural sampling.

9. Endrin

Among the various residential sites, endrin was detected in only the lawn and foundation samples from site 7. However, the endrin concentration in each of these samples is lower than the draft HBGL (4.0 mg/kg). Because endrin is a stereo-isomer of dieldrin with an extremely high K_{oc} value of 34000 (Kenaga, 1980) and an abnormally long degradation half-life of 2240 days (Wilkerson and Kim, 1986), its detection in soil is not surprising even if applied to the soil within the last 20 years.

Endrin residues likely resulted from structural pest control for homes because the compound was not detected in any of the public sites or found in the Phase I sampling. The two detections for endrin (0.2 and 1.2 mg/kg) were below the draft HBGL of 6.0 mg/kg.

10. Toxaphene

Like DDT, toxaphene was also a widely used agricultural pesticide in Arizona until the late 1960s. Even with an exceedingly low mobility as reflected by a K_{oc} value of 98600 (McDowell et al., 1981), the residual concentrations of toxaphene detected were much

lower than of those total DDT, chlordane, dieldrin and heptachlor. Given that its degradation half-life is only on the order of 69 days (Seiber et. al., 1979), unless it was recently applied, it is unlikely that toxaphene would be detected at a very high concentration. This might explain why toxaphene was only detected in a few cases among various residential and public sites.

Only samples from the lawn and foundation areas of site 6 among the residential sites contained toxaphene and the concentration at each of these areas was higher than the proposed HBGL (0.6 mg/kg).

Among the public sites, toxaphene was detected only in sites 9 and 15. The toxaphene concentration at the two athletic fields of site 9 was higher than the draft HBGL.

The low toxaphene concentrations are a carry-over from agricultural use. Toxaphene was consistently detected in the Phase I samples. The higher level of toxaphene that exceeded the HBGL was likely the result of supplemental use for site specific urban pest control. This hypothesis is supported by the fact that both sites 15 and 9 have not supported agricultural land uses since 1954.

11. 2,4-D

2,4-D is a phenoxy herbicide used specifically for broad-leaf weed control. 2,4-D can exist as salts (sodium, ammonium, amine, etc.) and esters (butyl, ethylhexyl, etc). Once applied, all forms of 2,4-D hydrolyze rapidly to 2,4-D acid. 2,4-D has a rather short dissipation half-life (Steward and Gaul, 1977; Wilson and Cheng, 1976 and Radosevich and Winterlin, 1977) and extremely low K_{oc} (Rao and Davidson, 1982; Grover and Smith, 1974 and Grover, 1977). It is highly unlikely that 2,4-D would be detected in the soil sampled in this study unless it was recently applied.

Among the residential sites, 2,4-D acid was only detected in the lawn and foundation of site 8. The concentrations at all of these areas are lower than the draft HBGL (1400 mg/kg).

Among the public sites, only the sample from the play area (0-6") of site 14 contained 0.05 mg/kg 2,4-D acid which is also much lower than the draft HBGL (1400 mg/kg).

The presence of 2,4-D in residential and public sites is probably the result of recent 2,4-D application for broad-leaf weed control rather than past agricultural practices since sites 8 and 14 last supported agricultural uses in 1958.

12. Ziram

Ziram is a dithio carbamate chemical used specifically as a foliar fungicide and seed treatment. No hypothesis has been developed to explain its presence in the subsoil (15-30 cm) of the play area and athletic field of sites 3 and 10 corresponding to the residential and public sites, respectively. No HBGL has been established for Ziram.

13. Aldrin

Among the various residential sites, aldrin was only detected in the sample from the foundation of site 1. Given that aldrin tends to transform photochemically and metabolically to dieldrin (Verschueren, 1983; Eichelberger and Lichtenberg, 1971 and Patil, 1972), the rather high dieldrin concentration in the foundation of site 1 (30 mg/kg) might have resulted from this transformation. Judging from its rather high concentration detected in the foundation (9.7 mg/kg) and moderately long dissipation half-life (Verschueren, 1983; Voerman, 1975; Lichtenstein et al., 1960 and Lichtenstein and Schulz, 1959), aldrin might have been used as a structural pest control chemical at site 1 within the last ten years. The sole detection of 9.7 mg/kg exceeded the draft HBGL of 0.04 mg/kg. Aldrin was not detected in any of the public sites.

C. Comparisons between School/Parks, Residential Sites, and the Control Sites

Schools/Parks vs. Residential Sites

Pesticides were generally detected in higher numbers and concentrations in residential samples when compared to the schools/parks samples. The residential samples generally had consistent detections of chlordane and dieldrin; and detections of DDT, DDE, and DDD. There were sporadic detections of heptachlor, heptachlor epoxide, ziram, endosulfan I, and endrin. In contrast, the schools/parks samples had fewer detections of chlordane, dieldrin, DDT, DDD, and DDE, and no detections of heptachlor, heptachlor epoxide, endosulfan I, and endrin.

Chlordane was detected in 23 of the 28 residential samples. Dieldrin was detected in 20 of the 28 samples. For comparison, chlordane was detected in only 2 of the 26 schools/parks samples. Dieldrin was not detected at all in the schools/parks samples.

The compounds DDT and/or DDE, and/or DDD appeared in 15 of the 26 schools/parks samples. By contrast, those compounds appeared in 21 of the 28 residential samples. There were also higher residuals in the residential samples with an average (geometric) concentration per detection of .63 mg/kg compared to 0.09 mg/kg in the schools/parks samples.

Toxaphene was detected in three residential samples and in four school/parks samples. The compound 2,4-D was detected in two residential samples, and in one schools/parks sample. In the residential areas, heptachlor appeared once, heptachlor epoxide three times, ziram once, endosulfan I once, and endrin twice. Those compounds were not detected in the school/park samples.

Arsenic had an average (geometric) concentration per detection of 17.8 mg/kg and 18.7 mg/kg for the schools/parks and residential samples, respectively.

Schools/Parks vs. Tempe Control Site (Meyer School)

The schools/parks in west central Phoenix had detections for chlordane, DDT, DDD, and DDE, toxaphene, ziram, and 2,4-D. None of these were detected in the Meyer School site in Tempe.

Arsenic was detected at an average (geometric) sample concentration of 20 mg/kg for the control site and 17.8 mg/kg for the west central Phoenix sites.

Residential Sites vs. Control Residential Site in Tempe

The control site in Tempe generally had fewer detections of pesticides and lower concentration levels of the compounds compared with the residential sites in west central Phoenix.

Chlordane was detected at an average (geometric) concentration per detection of 1.67 mg/kg in the Tempe site. The average (geometric) concentration per detection was 2.7 mg/kg in the west central Phoenix residential sites. The chlordane found at the Tempe site falls within the range of concentrations (0.2 to 290 mg/kg) for the west central Phoenix residences.

Dieldrin was detected at an average (geometric) concentration of 0.12 mg/kg in the Tempe site. The compound had a higher average concentration per sample of 2.6 mg/kg for the west central Phoenix residential sites. The concentrations at the Tempe site were below the range of dieldrin concentrations (.25 to 47 mg/kg) for the west central Phoenix residences.

DDT, DDD, and DDE were detected at an average (geometric) concentration of .35 mg/kg in the Tempe control site. The average concentration per sample for the west central Phoenix sites is higher at .67 mg/kg.

The control site average falls within the range of detected concentrations for the west central Phoenix samples (.05 to 3.8 mg/kg).

The compounds heptachlor, heptachlor epoxide, endrin, toxaphene, ziram, endosulfan I and 2,4-D were detected at the west central Phoenix residential sites. They were not detected at the control site.

Arsenic levels were similar with average (geometric) concentrations of 20.1 and 18.6 mg/kg at the control site and west central Phoenix sites, respectively.

D. Relationships among Chlordane, Dieldrin and Total DDT in Soil of the Residential Sites

Results of linear regression and correlation analysis conducted on the overall data as well as the data associated with the foundation and lawn samples from the residential sites are shown in Table 21. When the overall data is used, the concentrations of chlordane, total DDT and dieldrin are highly correlated (at p=0.05) with each other indicating a close relationship among these compounds. Only the concentration of chlordane is correlated significantly (at p=0.05) with that of total DDT when the data corresponding to the foundation samples is used.

When the linear regression analysis is conducted on the data from the lawn samples of the residential sites, the correlations among chlordane, total DDT and dieldrin are not significant; thus reflecting the lack of a relationship among these three chemicals in the lawn area of residential sites. It is therefore possible that DDT and dieldrin were used in combination for general home use and DDT and Chlordane were used in combination for applications to foundation areas.

Table 21. The Coefficient of Correlation (r) Between Chlordane, Total DDT Compounds and Dieldrin of the Residential Sites

Parameter	Overall		Foundation		Lawn	
	r	n	r	n	r	n
Chlordane vs. Dieldrin	0.84 **	18	0.71 ns	7	0.67 ns	6
Chlordane vs Total DDT	0.75 **	16	0.84 *	6	0.06 ns	5
Dieldrin vs. Total DDT	0.60 *	12	0.60 ns	10	0.27 ns	5

** Significant at p<0.01

* Significant at p<0.05

ns Non-significant at p>0.05

E. Comparison of Arsenic and Total DDT among Residential, Public (Phase II) and Agricultural Locations (Phase I Resampling)

1. Arsenic

The results shown in Table 22 indicate that the variation in the mean concentration of arsenic at 0-6" among the residential, public and agricultural sectors was not significant at p>0.05; at the same time, the mean arsenic concentration in each of these locations was well below that normally found in native soil (Dragon, 1988). Therefore, these results suggest that very low volumes of arsenic-containing defoliants such as cacodylic acid and arsenic acid were used in various sites of these three locations.

Where such defoliant compounds were used, it is probable that the residual concentrations are so low that they are masked by the natural arsenic levels.

2. Total DDT

The results in Table 22 show that the soil samples from the residential sector contain a significantly higher total DDT concentration than those from the public sector at $p=0.01$. However, when the total DDT concentrations of the foundation samples of the residential sector are excluded from the ANOVA, the difference is not significant. Therefore, it is concluded that the significantly higher total DDT concentrations associated with the residential sector compared to the public sector results from the extremely high total DDT concentration detected in the foundations of sites 1, 2, 3, 5, 7 and 8. At the same time, the results in Table 22 indicate that the difference in the mean total DDT concentration among the residential, public and agricultural sectors is not significant at $p>0.05$. The higher concentrations of DDT in the foundations of residential sites possibly result from the past use of DDT for termite control.

3. Toxaphene

Toxaphene was not compared because it occurred sporadically in the Phase II sampling (7 out of 54 samples), and the small detection rate would make any analytical comparison meaningless.

F. Comparison of the Residential and Public Sites with the Control with Respect to Arsenic, Chlordane, Total DDT and Dieldrin Concentrations.

The confidence interval of the geometric mean ($CI_{0.95}$) of arsenic, chlordane, dieldrin and total DDT of various areas in both residential and public sectors are shown in Table 23 and a comparison is made with the corresponding concentrations of the control sites.

Table 22. Analysis of Variance (ANOVA) on Arsenic and Total DDT among Residential, Public and Agricultural Sectors

Source	Residue	F-value
Residential vs Public	Arsenic	0.10 ns[@]
Residential vs. Agricultural	Arsenic	0.92 ns
Public vs. Agricultural	Arsenic	0.56 ns
Residential vs. Public (all data)	Total DDT	13.0 **[&]
Residential vs. Public (excluding structural data)	Total DDT	0.47 ns
Residential vs. Agricultural (all data)	Total DDT	1.22 ns
Residential vs. Agricultural (excluding structural data)	Total DDT	0.03 ns
Public vs. Agricultural	Total DDT	3.06 ns

[@] Non-significant at $p>0.05$.
[&] Significant at $p<0.01$.

1. Arsenic

The concentration of arsenic in both the lawn and foundation samples of the residential control site was within the corresponding confidence interval of the geometric mean shown in Table 23; therefore, it is concluded that the control site is not significantly different from the residential sites with respect to the concentration of arsenic in both lawn and foundation.

Given that the concentrations of arsenic in both athletic fields of the public control site are outside the lower end of the corresponding confidence interval of the geometric mean of arsenic (Table 23), it is concluded that the two athletic fields of the public control site contained significantly less arsenic than the corresponding arsenic concentration of various public sites. By the same analogy, the concentration of arsenic in the play area (0-15cm) of the public control site was significantly higher than the corresponding arsenic concentration of various public sites (Table 23).

Regardless of the outcome of the above comparisons, the concentration of arsenic of the various areas at all sites in both residential and public sectors was within the range of arsenic normally found in natural soil (Dragon, 1989).

2. Chlordane

The chlordane concentration in the foundation of the residential control site is less than the lower end of the corresponding confidence interval of the geometric mean (Table 23); this, together with the non-detection of chlordane (method detection limit=0.05 mg/kg) in the lawn of the same site, suggests that the chlordane concentrations of these areas are significantly lower than the corresponding concentrations associated with the various residential sites.

With the exception of the play area at Sueno Park, chlordane was not detected in any areas of the public sites and public control site; therefore, no comparison with respect to the chlordane concentration was made.

3. Total DDT

Given that the total DDT concentration in both the lawn and foundation of the residential control site lies within the corresponding confidence interval of the geometric mean (Table 23), it is concluded that this concentration is not significantly different from those associated with the various residential sites.

On the other hand, the non-detection of DDT and its metabolites (method detection limits of DDT, DDD and DDE were 0.01, 0.01 and 0.01 mg/kg, respectively) in both athletic fields of the public control site as shown in Table 23 when compared to those of other public sites indicated that the difference was significant. The west central Phoenix sites did demonstrate total DDT residuals.

4. Dieldrin

The data shown in Table 23 indicate that the concentration of dieldrin in the lawn and foundation of the residential control site was significantly lower than the corresponding dieldrin concentrations associated with the various residential sites.

Dieldrin was not detected in any public sites including the control; therefore, no comparison was necessary.

Table 23. Geometric Mean (X), Confidence Interval of the Geometric Mean ($CI_{0.95}$) of Arsenic, Chlordane, Dieldrin and Total DDT of Residential and Public Areas

Chemical	Area	X	$CI_{0.95}$	Control
			mg/kg	
Residential				
Arsenic	Lawn	17.8	14.3-22.1	16.0
	Foundation	20.1	15.2-26.5	24.0
Chlordane	Lawn	0.8	0.3-2.2	ND
	Foundation	13.0	1.7-101.4	1.4
Total DDT[@]	Lawn	0.31	0.05-1.72	0.17
	Foundation	1.86	0.11-6.20	0.50
Dieldrin	Lawn	0.9	0.2-4.7	0.04
	Foundation	15.9	5.2-49.2	0.2
Public				
Arsenic	Athletic 1	23.6	19.9-28.1	18.0
	Athletic 2	22.6	20.3-25.0	17.0
	Play area (0-15 cm)	8.0	4.3-15.0	18.0
Total DDT	Athletic 1	0.08	0.01-0.66	ND
	Athletic 2	0.14	0.04-0.53	ND

[@] Total DDT=DDD+DDE+DDT

VIII. Phase II Comparisons with Other Studies

An in-depth literature search was undertaken to gather data on pesticide residuals in urban soils from studies conducted in the United States. The search involved the use of the libraries at Arizona State University, University of Arizona, Arizona Department of Health Services, City of Phoenix, and ADEQ. Much of the search involved the use of computer line searches tapping into various databases.

The search indicated that many pesticide residual studies were performed during the late 1960s and early 1970s. They were sponsored by the National Pesticides Monitoring Program. The studies covered pesticide residuals in many cities across the United States.

In Table 24, the west central Phoenix data is compared with those cities selected for study in 1969 and 1971. The west central Phoenix data is presented as a composite of readings of non-structural areas of the residential samples (17), and structural areas of residential samples (8).

Given the extremely high variability of the database with respect to the ranges of the concentrations of pesticides detected at West Central Phoenix, the geometric mean is more appropriate than the arithmetic mean. Therefore, it is imperative that geometric mean instead of arithmetic mean should be used for comparison purposes.

Among the residential sites, West Central Phoenix had a significantly lower geometric mean for the detection of structural chlordane than the studies conducted at New Orleans (LA) and North Carolina (13.0 mg/kg vs. 651 mg/kg and 1182 mg/kg, respectively). However, an extremely large coefficient of variation (CV) for chlordane concentration was observed in both studies (Table 25); thus indicating the great variability of the sites in each study.For the non-structural samples at residential areas, the geometric mean for chlordane at West Central Phoenix was significantly higher than those associated with the studies at Baltimore (MD), Gadsden (AL), Hartford (CT), Macon (GA) and Newport News (VA) (0.8 mg/kg vs. 0.016 mg/kg, 0.002 mg/kg, 0.067 mg/kg, 0.012 mg/kg and 0.007 mg/kg, respectively).

Table 24. Comparison of Pesticide Residues in Urban Soils

	WEST CENTRAL PHOENIX - 1990 49 Total Samples (Res., Public areas) 0-6" Depth			WEST CENTRAL PHOENIX - 1990 25 Total Samples (Res. only) 0-6" Depth (L, S)			WEST CENTRAL PHOENIX - 1990 17 Samples (L only) 0-6" Depth			WEST CENTRAL PHOENIX - 1990 8 Samples (S only) 0-6" Depth		
	Range	Geom Mean	% DET	Range	Geom Mean	% DET	Range	Geom Mean	% DET	Range	Geom Mean	% DET
Chlordane	.07 - 290	2.1	47	.2 - 290	2.7	84	.15 - 8	0.8	82	.25 - 290	52.43	100
Dieldrin	.25 - 47	2.6	35	.25 - 47	2.6	68	.25 - 14	0.9	65	6.0 - 47	17.13	75
Heptachlor	4.2	---	2	4.2	---	4	---	---	---	4.2	4.2	12
Heptachlor Epox.	.1 - .8	.13	6	.03 - .8	.13	12	.03 - .1	0.05	12	.8	0.8	12
Toxaphene	.1 - 1.0	.57	14	1.0 - 1.0	1.0	12	1.0	1.0	12	1.0	1.0	12

	NEW ORLEANS, LA - 1986 [1] 240 Samples 0-4" Depth (S)			NORTH CAROLINA - 1983 [2] 71 Samples 0-4", 4-8" Depth (S)			BALTIMORE, MD - 1971 [3] 156 Samples 0-3" Depth (L, W)			GADSDEN, AL - 1971 55 Samples [3] 0-3" Depth (L, W)			HARTFORD, CT - 1971 [3] 48 Samples 0-3" Depth (L, W)		
	Range	Geom Mean	% DET	Range	Geom Mean	% DET	Range	Geom Mean	% DET	Range	Geom Mean	% DET	Range	Geom Mean	% DET
Chlordane	.6 - 14464	651	100	283 3324	1182	93	.01 - 12.35	0.016	37	.04 - .46	0.002	5	.02 - 141	0.067	48
Dieldrin	---	---	---	---	---	---	.01 - 1.4	0.003	19	.01 - .04	<0.001	13	.08 - 1.4	0.004	10
Heptachlor	---	---	---	14-635	296*	92	ND	ND	ND	ND	ND	ND	.13	---	2
Heptachlor Epox.	---	---	---	---	---	---	.09 - .17	<0.001	3	.04	---	2	.01 - 1.9	0.004	15
Toxaphene	---	---	---	---	---	---	ND	---	---	ND	---	---	ND	---	---

--- = Data not avaliable
DET = Detection
ND = No detection

L = Lawn
S = Structural
U = Unkept areas
W = Waste

* Based on 40 samples

Table 24. Comparison of Pesticide Residues in Urban Soils (Cont)

	MACON, GA - 1971 [3] 43 Samples 0-3" Depth (L, W)			NEWPORT NEWS, VA - 1971 [3] 78 Samples 0-3" Depth (L, W)			BAKERSFIELD, CA - 1969 [4] 50 Samples 0-3" Depth (L, U)			CAMDEN, NJ - 1969 [4] 50 Samples 0-3" Depth (L, U)			HOUSTON, TX - 1969 [4] 50 Samples 0-3" Depth (L, U)		
	Range	Geom Mean	% DET	Range	Geom Mean	% DET	Range	Geom Mean	% DET	Range	Arith Mean	% DET	Range	Arith Mean	% DET
Chlordane	.07 - .91	0.012	26	.09 - 7.29	0.007	13	.07 - 20.48	.78	30	.39 - 5.9	.36	16	.04 - 12.9	.66	34
Dieldrin	.01 - 6.02	0.01	30	.01 - 1.9	0.002	9	.01 - 1.9	.07	28	.02 .21	<.01	4	.01 1.5	.04	20
Heptachlor	.01 - .01	<0.001	5	.02 - .03	<0.001	3	.02 - .10	<.01	4	ND	ND	---	.01 .02	<.01	6
Heptachlor Epox.	.01 - .14	<0.004	21	.04 - .2	<0.001	4	.05 - .18	.01	8	.02 - .39	.01	6	.01 - .14	<.01	20
Toxaphene	.23 - 5	0.019	26	ND	---	---	ND	---	---	ND	---	---	.11	<.01	2

	MANHATTAN, KS - 1969 [4] 50 Samples 0-3" Depth (L, U)			MIAMI, FL - 1969 [4] 50 Samples 0-3" Depth (L, U)			MILWAUKEE, WS - 1969 [4] 50 Samples 0-3" Depth (L, U)			SALT LAKE CITY, UT - 1969 [4] 50 Samples 0-3" Depth (L, U)			WATERBURY, CT - 1969 [4] 50 Samples 0-3" Depth (L, U)		
	Range	Arith Mean	% DET	Range	Arith Mean	% DET	Range	Arith Mean	% DET	Range	Arith Mean	% DET	Range	Arith Mean	% DET
Chlordane	.03 - 4.9	.30	40	.04- 16.9	1.59	64	.05 - 10.2	.45	34	.02 - 7.5	.41	38	.02 -8.7	.96	28
Dieldrin	.01 - .72	.04	20	.01- 8.58	.72	64	.01 - 1.4	.04	20	.01 - 1.14	.03	26	.02 -.22	.01	8
Heptachlor	.02 - .09	<.01	10	.01 - .02	<.01	6	.02 - .45	.02	12	.01 - .24	.01	12	.01 - .53	.01	8
Heptachlor Epox.	.01 - .44	.03	26	.01- .45	.05	50	.01- .52	.04	32	.01 - .23	.02	26	.01 - .53	.02	30
Toxaphene	12.07	.24	2	14.8 - 52.7	1.34	4	ND	---	---	ND	---	---	ND	---	---

--- = Data not avaliable
DET = Detection
ND = No detection

L = Lawn
S = Structural
U = Unkept areas
W = Waste

* Based on 40 samples

1. From Delaplane and LaFage (1990).
2. From Leidy et.al. (1985).
3. From Carey el al. (1979).
4. From Wiersma el al. (1972).

Table 25. The Coefficient of Variation (CV) of Foundation Chlordane Residues as Compared to those Reported by Delaplane and La Fage (1990)

Source	No. of Sample(s)	CV
Greater New Orleans, La		
Construction Type		
Slab	13	127.4%
Crawl/Slab	4	123.1%
Crawl	10	93.3%
	Weighted Mean	114.6%
West Central Phoenix, Az		
	8	190.0%

One can argue that any comparison with respect to the chlordane concentration for these two studies is not appropriate since the data reported by Delaplane and La Fage (1990) was associated with a soil depth of 0-5 cm and 6-10 cm, whereas in this study, the soil was sampled at 0-15 cm. However, the rather low chlordane concentration detected in the foundation samples of this study as compared to those reported by Delaplane and La Fage (1990) might be explained by one or more of the following reasons:

1. The soil bulk density associated with this study was significantly higher than that encountered in the Louisiana study; therefore, for a given depth, the mass of soil was greater in the former than the latter thus causing a dilution effect on the chlordane.

2. Although the total organic carbon of the soil in the residential sample sites of west central Phoenix was low, given the high K_{oc} of chlordane, the leaching of the surface applied chlordane to the subsoil was very limited.

3. The relatively low chlordane concentration detected in the foundation samples in this study is not surprising given the fact that between 75-100% chlordane would typically be dissipated from soil in 3-5 years (Edwards, 1966; Kearney et al., 1965).

4. The chlordane concentration used for termite control in Arizona is lower than in Louisiana.

Within the non-structural samples of U.S. residential areas, the chlordane detections for west central Phoenix had the highest detection rate (i.e. number of samples with chlordane). However, the range of detections (.15 - 8 mg/kg) was less than Baltimore, Maryland (.01 - 12.35 mg/kg), Hartford, Connecticut (.02 - 16.9 mg/kg), Bakersfield, California (.07 - 20.48 mg/kg), Houston, Texas (.04 - 12.9 mg/kg), Miami, Florida (.04 - 16.9 mg/kg), Milwaukee, Wisconsin (.05 - 10.2 mg/kg) and Waterbury, Connecticut (.02 -8.7 mg/kg).

The comparison of detected levels of structural dieldrin among residential sites in West Central Phoenix with those of New Orleans (LA) and North Carolina was not possible given that the latter two studies did not contain any data for dieldrin. For the non-structural samples at residential areas, the geometric mean for dieldrin at West Central Phoenix was significantly higher than those associated with the studies at Baltimore (MD), Gadsden (AL), Hartford (CT), Macon (GA), and Newport News (VA) (15.9 mg/kg vs. 0.003 mg/kg, <0.001 mg/kg, 0.004 mg/kg, 0.01 mg/kg and 0.002 mg/kg, respectively).

In the West Central Phoenix study, only residential site #1 was detected with structural Hepachlor, the concentration of which was significantly lower than the corresponding geometric mean associated with the study conducted at North Carolina (4.2 mg/kg vs. 296 mg/kg). No heptachlor was detected in any of the non-structural samples in the West Central Phoenix study.

Only residential site #8 of West Central Phoenix was detected with structural heptachlor epoxide and its comparison with those of the studies at New Orleans (LA) and North Carolina was not possible because the latter two studies did not contain any information on the structural heptachlor epoxide. For the non-structural samples, only site #7 and site #8 were detected with heptachlor epoxide. The geometric mean concentration was significantly higher than those associated with the studies conducted at Baltimore (MD), Hartford (CT), Macon (GA) and Newport News (VA) (0.5 mg/kg vs. <0.001 mg/kg, 0.004 mg/kg, <0.001 mg/kg and <0.001 mg/kg, respectively).

In the West Central Phoenix study, only residential site #6 was detected with structural toxaphene and a comparison to the studies conducted at New Orleans (LA) and North Carolina was not possible given that the latter two studies did not contain any data on structural toxaphene. At the same time, the non-structural toxaphene was only significantly higher than the corresponding geometric mean associated with the study conducted at Macon (GA) (1.0 mg/kg vs. 0.019 mg/kg.

The ranges and concentrations for heptachlor, heptachlor expoxide and toxaphene in west central Phoenix were similar to the values found in the other U.S. cities.

The concentrations of those compounds ranged up to 4.2 (structural sample), 1.0 (structural and lawn samples), and 0.8 (structural sample) mg/kg, respectively, in west central Phoenix. This compares to ranges as high as 635 (structural samples), 52.7 (non-structural samples), and 1.9 (non-structural samples) mg/kg, respectively, in other U.S. cities.

IX. **Conclusions and Recommendations**

The majority of chemical residuals found belong to the family of chlorinated hydrocarbons. Given that these chemicals were widely used for both agricultural and structural purposes in Arizona before being banned or withdrawn and given that they are generally known for their immobility and persistence in soil, their detection in the residential and public sites in west central Phoenix is not surprising.

The results from the Phase I sampling indicate that DDT, and its degradation products DDD, and DDE, and toxaphene were consistently identified in soil samples from agricultural sites. These residues result from past agricultural pesticide applications. Other chemicals were detected more sporadically in samples taken from agricultural sites due to variable cropping patterns or past infestations associated with agricultural uses at any given field site. Because of problems with the quality assurance/quality control practices of the contract laboratories, Phase I sample results could not be analyzed statistically.

The data from the Phase I resampling effort was of sufficient quality to provide a quantitative representation of the sites selected. Arsenic, DDT and toxaphene were detected consistently at the re-sampled agricultural sites. This was supportive of the qualitative findings of the earlier Phase I sampling. The DDT, DDD, DDE and toxaphene residuals are the result of previous agricultural activities. The arsenic detections were at normal levels for soils of the area. These arsenic residuals are probably not attributable to past agricultural practices.

Fifty-three compounds were analyzed as part of the urban sites (Phase II) sampling. The analytical data met acceptable quality assurance/quality control standards. Compounds frequently detected were lead, DDT, DDD, DDE, arsenic, chlordane and dieldrin. Compounds that were detected sporadically included toxaphene, heptachlor, heptachlor epoxide, diazinon, endosulfan I, endrin, ziram, 2,4-D and aldrin.

The pesticide residuals identified in Phase II were detected more often and at higher concentrations in the samples from residential sites than in the samples taken at school/park sites. This difference in residual concentration is most likely attributable to differences in structural pest control practices rather than to previous agricultural use.

The arsenic concentrations from Phase II samples were again within the range found in native soils. The presence of arsenic in the Phase II samples was not related to either structural pest control or agricultural practices.

Chlordane and dieldrin concentrations were greater in the samples taken adjacent to residential structures than in samples from lawn and garden areas. Furthermore, the compounds were not detected in the majority of the school/park samples. Chlordane and dieldrin residues likely resulted from residential structural pest control use.

DDT and its metabolites were present in 75 percent of the samples taken in the Phase II study. This suggests that DDT, DDD and DDE residues at residential sites are likely the result of agricultural practices. The compounds were found in higher concentrations adjacent to residential structures than either the school/park samples or the Phase I resamples. The higher concentrations in structural samples of the residential sites indicate the additional use of DDT, DDD and DDE in structural applications.

Heptachlor, heptachlor epoxide, endrin, and aldrin were detected sporadically in the residential areas, and were not detected in any of the school/park sites. They were not found in the Phase I samples. It is likely that these sporadic detections reflect a site specific pattern of application for residential structural pest control to treat a particular problem or infestation.

Toxaphene appeared sporadically in the residential areas and the school/park sites. The residual concentration of toxaphene was much lower than DDT, chlordane, dieldrin and heptachlor. Conversely, it was detected consistently in the Phase I sampling. The presence of the compound is probably a result of agricultural activities except where higher concentrations at residential sites suggest it may have been used at some homes for urban pest control.

The chlordane and dieldrin concentrations detected in the lawn and foundation of the residential control site at Tempe were lower than the geometric mean concentration for sample residential sites in west central Phoenix. The chlordane concentrations at the Tempe site fell within the range of concentrations for west Central Phoenix. The dieldrin concentrations detected at the control site were below the range of detections for west central Phoenix.

DDT, DDD and DDE were not detected at the control site, as was the case in 30 percent of the west central Phoenix public site samples. Based on the limited information, there is little reason to suggest that the residuals at the Tempe sites were significantly different than those in the West Central Phoenix area.

A study of pesticide residuals in residential soils in several cities was conducted during the late 1960s and early 1970s.

In addition, recent studies were conducted in New Orleans and North Carolina for chlordane residues. The data from these studies were compared with the data from west central Phoenix. The comparisons of data from the studies revealed that the dieldrin, heptachlor, heptachlor epoxide, and toxaphene residuals detected in the residential area of west central Phoenix are not significantly above or below the detections of other U.S. cities. The chlordane detections from west central Phoenix are significantly lower than the detections found in New Orleans and North Carolina.

In general, the data from this study indicate that soils from selected sites in the residential areas of the west central Phoenix area do not contain residuals from the wide variety of agricultural chemicals normally used in Arizona. The higher concentrations of chlordane, dieldrin, and other chlorinated hydrocarbons in the foundations of a number of residential sites when compared to lawn and garden areas, play areas, schools and parks, and agricultural areas, indicate that these residues resulted from application to the foundations as structural pest control.

Given that the residential site in Tempe contained a lower concentration of chlordane and dieldrin at its lawn and house foundation than the mean for residential sites sampled in west central Phoenix, it is advisable to include an analysis of these chemicals at similar sites in future case-control studies. Several other chemical residues were found associated with chlordane in the residential areas. It is recommended that the future case-control studies include analyses of all of the pesticides which were identified in Phase II of this study. This recommendation is consistent with one of the objectives of this study.

As stated earlier, there is a consistent pattern of pesticide residue that appears to be highly correlated with agricultural activity. The pesticides which are most prevalent in this regard are DDT and metabolites and toxaphene. In a number of cases, these pesticides were detected at levels which are above the recently published draft Health Based Guidance Levels.

Samples from this study and other efforts in the Phoenix metropolitan area indicate that it is fairly common place to find total DDT and toxaphene at levels above the HBGL. This brings up questions regarding the degree of health hazard, if any, these residuals may pose to the population. In order to answer these questions, however, the following tasks are recommended:

- Further testing of agricultural areas should be undertaken to characterize the nature and distribution of DDT and toxaphene in the Phoenix area. This testing should give consideration to any differences in soil residuals which may be related to past spraying for particular pest infestations. Sampling should be sufficient to support a human health and environmental risk assessment.

- The Health Based Guidance Levels for total DDT and toxaphene, in particular, should be expanded to consider risks from inhalation exposures. This pathway should also be included in the risk assessment process.

- Total DDT and toxaphene levels found in the Phoenix area should be evaluated by ADHS to determine if they represent a significant level of risk.

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APPENDIX A. RATIONALE FOR SOIL SAMPLES

Soil Sampling Method Proposed for the West Central Phoenix Project

The proposed soil sampling method for the West Central Phoenix Project is based on the assumption that the soil organic carbon is the only soil component responsible for pesticide adsorption. Such an assumption is supported by studies conducted by various investigators (Hamaker et al., 1966; Savage and Wauchope, 1974; Sheet et al., 1962; Sherbourne and Freed, 1954; Robert and Wilson, 1965), all of which indicate that soil organic matter is the best estimator of adsorption isotherm parameters. The spatial variability of soil organic matter content in an area of interest, therefore, can be used to determine with considerable confidence the sample size required to estimate the amount of soil-adsorbed pesticides.

The spatial variability of soil organic carbon content in some sites of the Maricopa Farm has been studied by Yu and Lewen (1987). The similarity in the usage pattern and soil texture among the Maricopa Farm and most agricultural regions in the west central Phoenix area enables us to estimate the sample size required for assessing the extent of pesticide contamination on the furrow slice (0-15cm) in the west central Phoenix area using data from the Maricopa Farm generated previously by the above two authors.

Deming (1960) suggested that the standard deviation of the population with respect to the parameter of interest can be estimated using the highest and lowest values of the population and the distribution pattern. Based on these, the standard deviations are thus estimated as follows:

$$S = 0.29D \text{ (uniform)} \quad \text{---------- (1)}$$
$$S = 0.21D \text{ (skew)} \quad \text{---------- (2)}$$

where D is the difference between the highest and lowest values and S is the standard deviation of the population. The uniform and skew distribution represent the largest and smallest estimation of the standard deviation, respectively. The standard deviation of a normally distributed parameter should fall within those corresponding to these two distributions. Hence, it is logical to assume that eq. (1) and eq. (2) form the upper and lower limits, respectively, of the standard deviation associated with the normal distribution pattern.

Assuming the parameter of interest is normally distributed, the 95% confidence limits computed from the sample mean (Snedecor and Cochran, 1976) are as follows:

$$X \pm 2S/N^{1/2} \quad \text{---------- (3)}$$

where X is the sample mean; S is the standard deviation and N is the sample size corresponding to the 95% confidence limit. Eq. (3) will allow us to estimate the allowable error in the

sample mean (L) by the following equation:

$$L = 2S/N^{1/2} \quad \text{---------- (4)}$$

Knowing the standard deviation of the population, the approximate sample size can be calculated by re-arranging eq. (4) to obtain eq. (5):

$$N = 4S^2/L^2 \quad \text{---------- (5)}$$

The maximum and minimum soil organic carbon contents in the Maricopa Farm are found to be 1.5% and 0.5%, respectively (Yu and Lewen, 1987). Assuming that the soil organic carbon in west central Phoenix is normally distributed, its largest possible standard deviation can be computed by eq. (1). The sample size required for the two distribution patterns is hence calculated using eq. (5). The result is shown in Table 1. The sample size required (L - 0.1%) for this project is calculated to be 34. This indicates that at least 34 soil samples should be taken from each selected site (assuming that each selected site shares a common variance with respect to the soil organic carbon content) if we are willing to take a 5% chance that the error will exceed L.

Once the sites of interest are selected, soil samples from each site should be taken either by random sampling or systematic sampling. Since each selected site is of considerable size (at least 6 acres), systematic sampling would provide more meaningful data with respect to the spatial variation of the parameter of interest.

With the systematic sampling, a gridded sampling pattern will be placed on the defined boundary of the selected site. Sample positions will be marked on the grid. The distance between each sampling position depends on the area of the sampling site and the sample size (a minimum of 34 in this case). In general, given a sample size, the larger the sampling area, the further the distance between each sampling position. An example of systematic sampling in an arbitrary area is shown in Fig. 1.

At each sampling position, the following processes will be followed: Five random samples (0-15cm) within a radius of 3m (10ft) will be obtained with a 7.6cm diameter bucket auger, fully mixed into a subsample. Each subsample should weigh at least 454g (1lb). The subsample from each sampling position (at least 34 in this case) within the sampling site will be composited to selected sites. The procedures of soil sampling, soil shipping and storage will be carried out in accordance with the protocols established by the Pesticides Unit of the Arizona Department of Environmental Quality. All the composite samples (equal to the number of sampling sites) will be sent to USEPA for pesticide characterization. In this way, the extent of pesticide contamination of the furrow slice in all selected sites will be known.

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APPENDIX B. SUMMARY OF DETECTION LIMITS

SUMMARY OF DETECTION LIMITS
Phase I Sampling
(mg/kg)

	ADEQ CONTRACT LAB	EPA CONTRACT LAB
INSECTICIDES		
ALDICARB	0.1	---
AZINPHOS-METHYL	1.0	---
BENZENE	1.0	---
CARBARYL	0.1	0.33
CARBOFURAN	0.1	---
CHLORDANE	0.3	0.067
DDT	0.005	0.13
DDE	0.005	0.13
DDD	0.005	0.13
DICROTOPHOS	0.5	---
DIELDRIN	0.005	0.013
DIMETHOATE	---	0.05
DISULFOTON	0.05	0.005
ENDOSULFAN I	0.005	---
ENDOSULFAN II	0.005	---
ENDOSULFAN SULFATE	0.02	---
ENDRIN (ALDEHYDE)	0.01	---
ENDRIN	0.01	0.013
EPN	0.2	---
ETHION	0.05	0.04
FENVALERATE	0.1	---
HEPTACHLOR	0.005	0.006
HEPTACHLOR EPOXIDE	0.005	---
LINDANE	0.005	---
METHOMYL	0.1	3.3
METHOXYCHLOR	0.02	0.067
METHYL PARATHION	0.05	0.010
MONOCROTOPHOS	1.0	---
PARATHION	0.05	---
PHORATE	0.05	---
PHOSPHAMIDON	---	0.1
PROFYENOFOS	---	0.1
STROBANE	0.05	0.067
SULPROFOS	---	0.50
TOXAPHENE	0.05	0.33
TRICHLORFON	0.2	---

SUMMARY OF DETECTION LIMITS
Phase I Sampling
(mg/kg)

	ADEQ CONTRACT LAB	EPA CONTRACT LAB
HERBICIDES		
2, 4-D	0.005	0.005
ARSENIC ACID	3.0	---
ATRAZINE	0.1	0.67
BENSULIDE	---	1.0
BROMACIL	0.1	0.013
CYANAZINE	0.1	0.06
DCPA	---	0.013
DINOSEB	0.005	0.002
DIURON	0.1	0.33
ENDOTHALL	3.0	---
MONURON	0.1	0.33
NAPROPAMIDE	0.1	3.3
PARAQUAT	---	0.5
PENDIMETHALIN	---	0.6
PROFLURALIN	0.02	0.03
PRONAMIDE	0.02	0.026
PROPHAM	0.1	3.3
SILVEX	0.005	0.002
TEBUTHIURON	0.1	3.3
TRIFLURALIN	---	0.013
OTHER		
CAPTAN	0.02	0.013
DEF	---	0.04
DICOFOL	0.02	0.013
MANEB	1.0	---
TERRAZOLE	---	0.026
ACEPHATE	---	0.04
2,4-DB	---	---

SUMMARY OF DETECTION LIMITS
Phase I Resampling/Phase II Sampling
(mg/kg)

	ADEQ CONTRACT LAB
INSECTICIDES	
ALDRIN	0.005
ALPHA-BHC	0.005
AROCLOR 1016	0.05
1221	0.05
1232	0.05
1242	0.05
1248	0.05
1254	0.05
1260	0.05
AZINPHOS-METHYL	0.30
BETA-BHC	0.005
GAMMA-BHC (LINDANE)	0.005
DELTA BHC	0.005
CHLORDANE	0.05
CARBOFURAN	1.7
CARBARYL	2.0
DEMETRON	0.06
DDD	0.01
DDE	0.01
DDT	0.01
DIAZINON	0.06
DIELDRIN	0.01
DISULFOTON	0.06
ENDOSULFAN I	0.01
ENDOSULFAN II	0.01
ENDOSULFAN SULFATE	0.01
ENDRIN	0.01
ENDRIN (ALDEHYDE)	0.01
ENDRIN (KETONE)	0.01
ETHION	0.10
ETHYL PARATHION	0.06
HEPTACHLOR	0.005
HEPTACHLOR EPOXIDE	0.005
MALATHION	0.06
METHOMYL	5.0
METHYL PARATHION	0.06

SUMMARY OF DETECTION LIMITS
Phase I Resampling/Phase II Sampling
(mg/kg)

	ADEQ CONTRACT LAB
INSECTICIDES	
METHOXYCHLOR	0.05
OXAMYL	0.33
PROPUXUR	1.7
TOXAPHENE	0.01
Herbicides	
2,4-D	0.04
2,4-DB	0.04
2,4-5-T	0.02
BROMACIL	2.0
CHLORPROPHAM	0.33
DICAMBA	---
DINOSEB	0.04
DIURON	1.0
LINURON	0.17
NEBURON	0.17
SILVEX	0.02