

# A Study of the Association Between Cancer Rates and TCE Ground Water Contamination in Communities Surrounding Hill Air Force Base, Utah from 1973 - 2001



## Environmental Epidemiology Program

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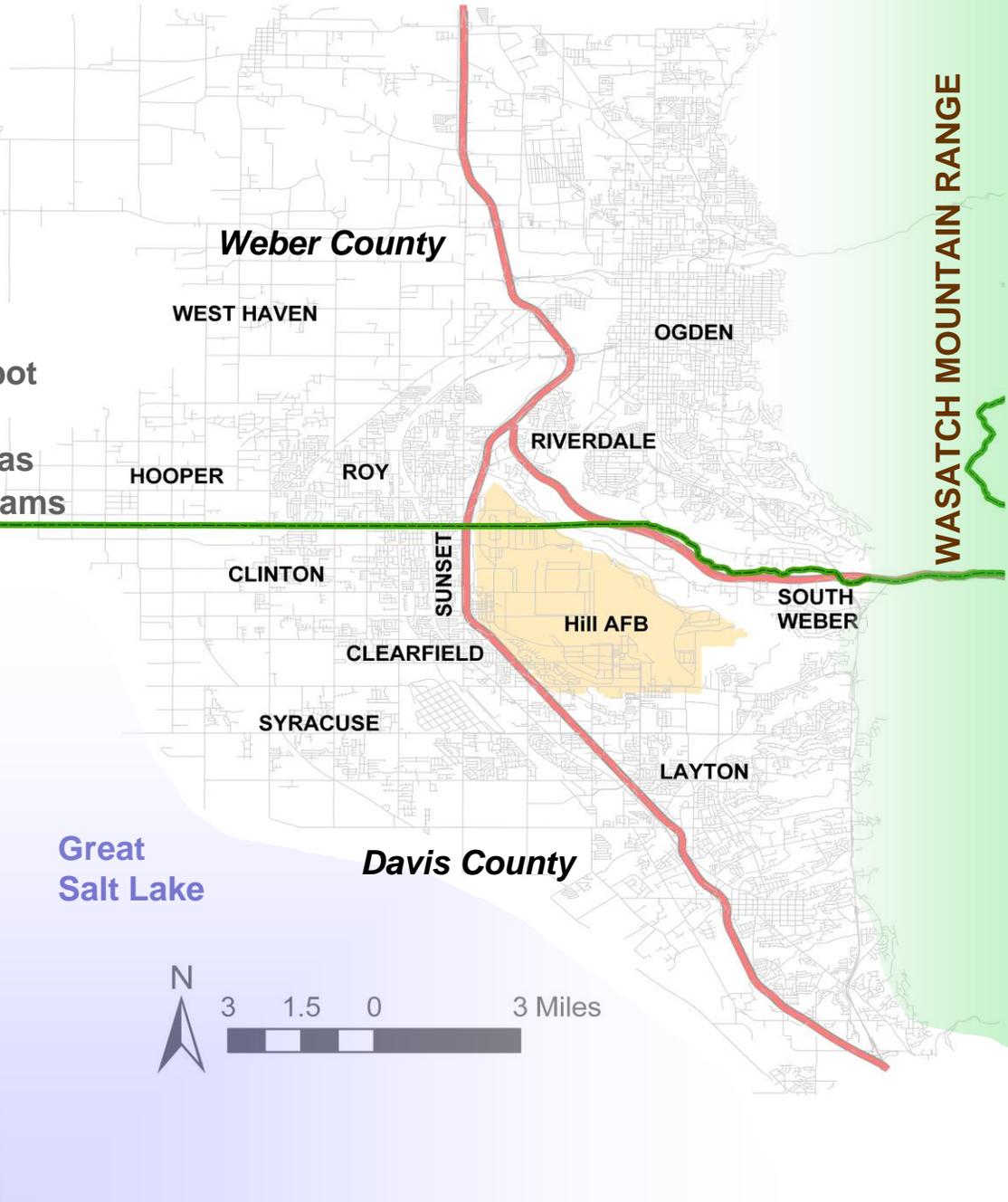
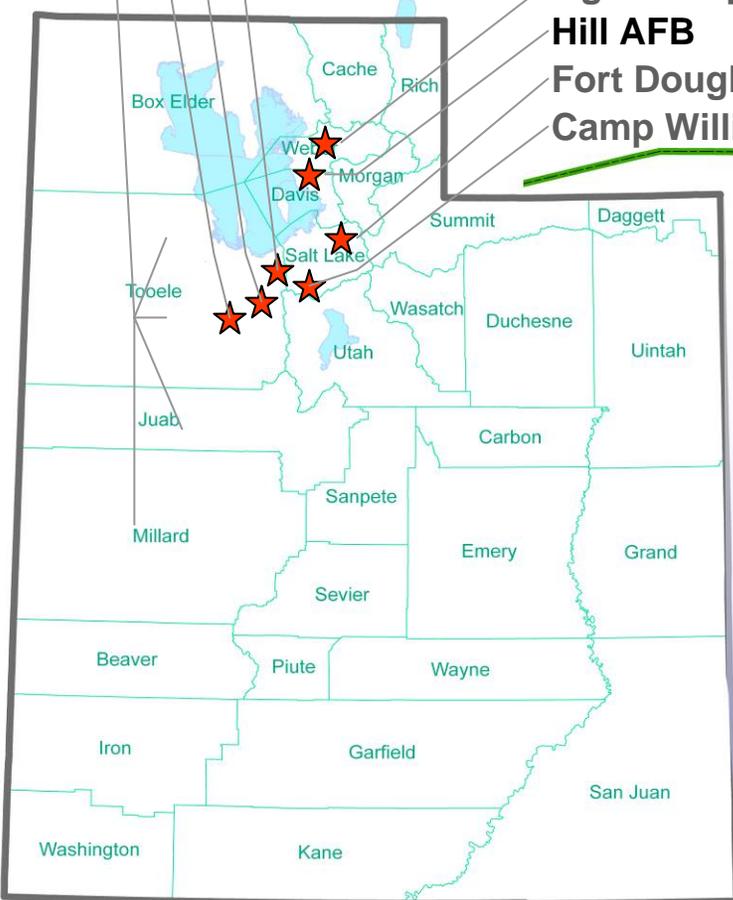
## Huntsman Cancer Institute

University of Utah

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**West Desert Test Range**  
**Dugway Proving Ground**  
**Deseret Chemical Depot**  
**Tooele Army Depot**

**Ogden Depot**  
**Hill AFB**  
**Fort Douglas**  
**Camp Williams**



**Great Salt Lake**

**WASATCH MOUNTAIN RANGE**

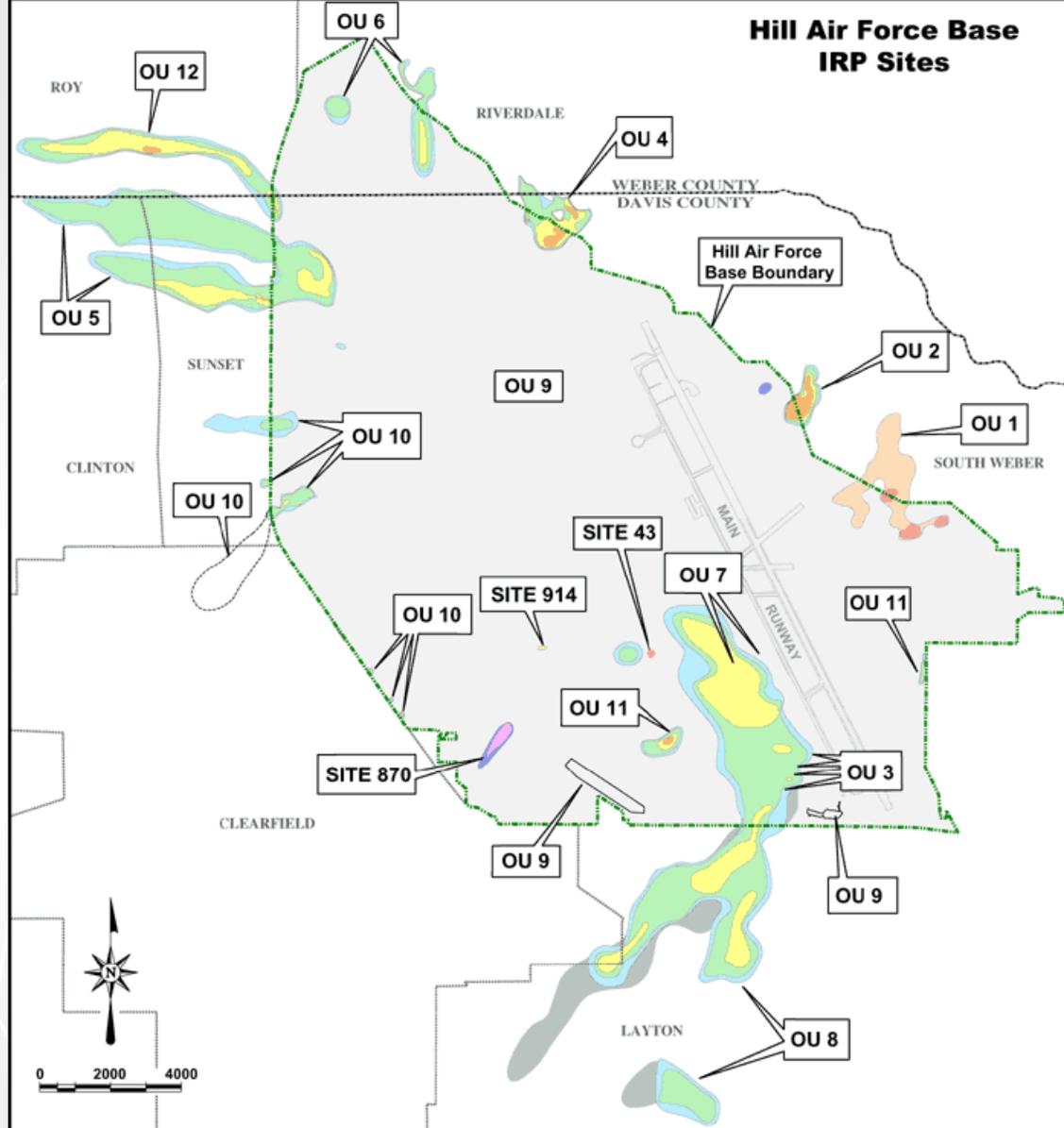


# Hill Air Force Base

- ▶ Started as an Army Air Mail Port in 1934.
- ▶ Construction for Hill Field began in January 1940 and Hill Field becomes operational in November 1940.
- ▶ Logistics support, maintenance and depot operations began in 1950.
- ▶ Started investigation of environmental contamination in 1976.
- ▶ EPA places Hill AFB on Superfund NPL in Jul 1987.
- ▶ Control and clean up work began in 19\_\_

## Contaminants

- Trichloroethylene
- Tetrachloroethylene
- Carbon Tetrachloride
- Perchlorate



ST061 and ST068 show petroleum hydrocarbon isoconcentration contour lines	OU 2, 4, 5, 6, 8, 10, and 11 show TCE isoconcentration contour lines	OU 11 shows - Bldg 454 shows MTBE isoconcentration contour lines	OU 1 shows 1,2-DCE isoconcentration contour lines
<ul style="list-style-type: none"> <li>■ Extent of ground-water contamination</li> <li>■ Extent of LNAPL</li> </ul>	<ul style="list-style-type: none"> <li>■ 5-10</li> <li>■ 10-100</li> <li>■ 100-1,000</li> <li>■ 1,000-10,000</li> <li>■ &gt;10,000</li> </ul>	<ul style="list-style-type: none"> <li>■ 5-10</li> <li>■ 10-100</li> <li>■ 100-1,000</li> <li>■ 1,000-10,000</li> </ul>	<ul style="list-style-type: none"> <li>■ 70-1,000</li> <li>■ &gt;1,000</li> <li>■ OU 8</li> <li>■ 1,2-DCA plume</li> </ul>

Note: Colored areas show ground-water contamination above primary MCLs. Concentrations are in micrograms/liters (ug/l).

# Why?

- ▶ Respond to a public concern of perceived clustering of cancer
- ▶ Explore integrate residential tenure and familial history data into cluster analysis
- ▶ Integrate spatio-temporal analytical methods
  - Rapid Inquiry Facility
  - SaTScan



Utah Cancer Registry



Street Address Data



Tool Development



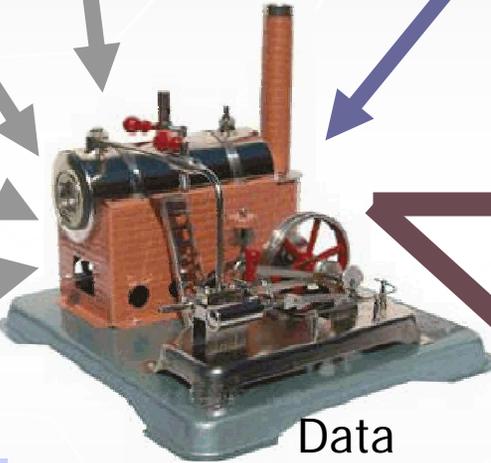
US Census Population



Utah Population Database



Plume Data  
Hill Air Force Base  
Environmental



Data Preparation



Spatial Reference Data



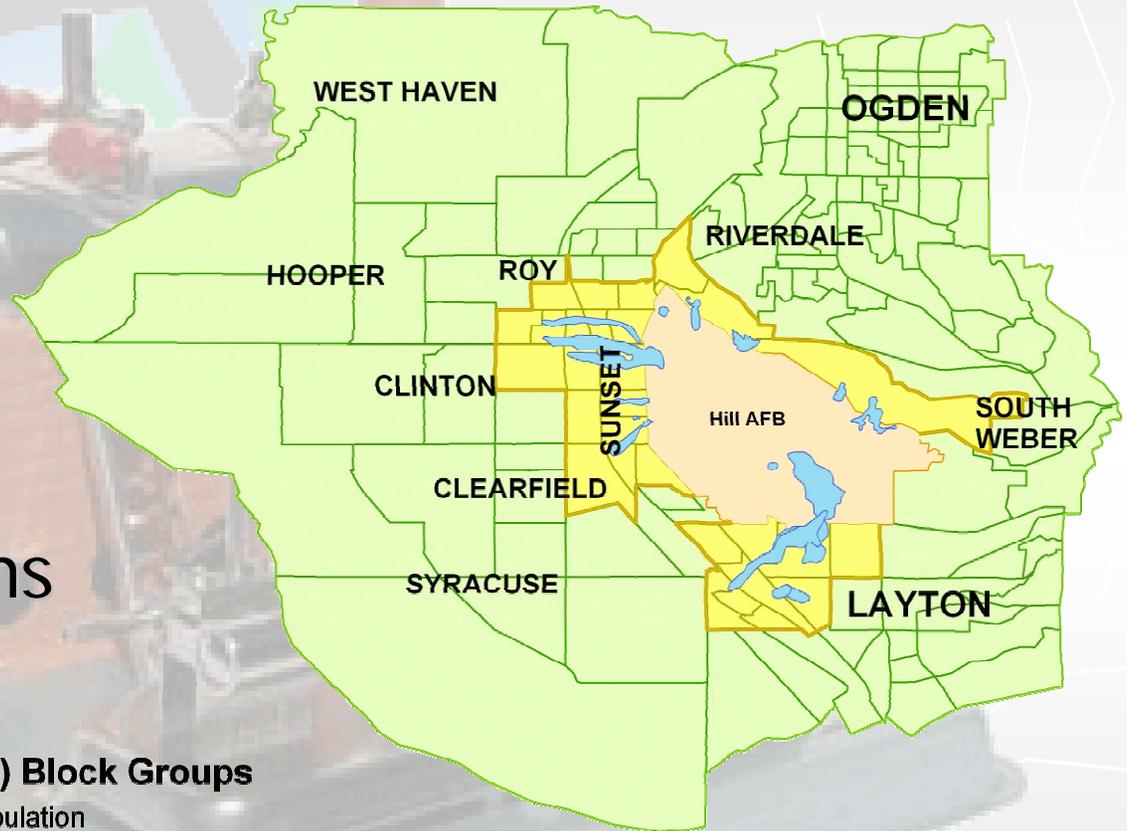
Spatial Analysis



Rapid Inquiry Facility

# Data Preparation: The Study Area

- ▶ 11 Zip Codes
- ▶ 143 Census Block Groups
- ▶ 247,000 Persons



## Census (2000) Block Groups

- Exposed Population
- Unexposed Population
- Contaminated Ground Water Plumes



# Data Preparation: Cancer Cases

## Geocoding

▶ Primary Cases	11,232
▶ Geocoded	11,113 (98.9%)
▶ Not Geocoded	119 ( 1.1%)

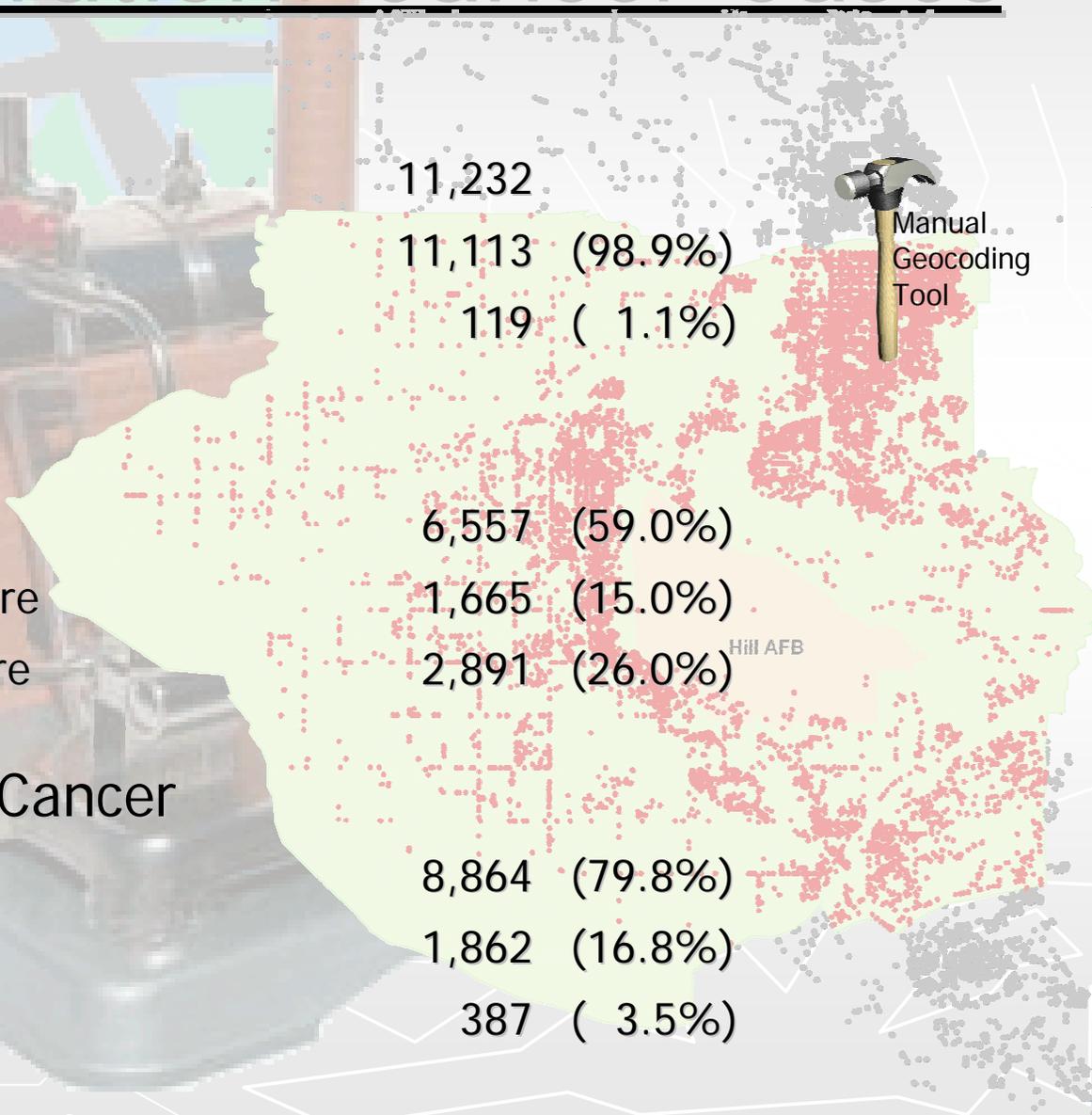


## Residential Tenure

▶ Unknown	6,557 (59.0%)
▶ Short Residential Tenure	1,665 (15.0%)
▶ Long Residential Tenure	2,891 (26.0%)

## Familial History of Cancer

▶ Unknown	8,864 (79.8%)
▶ No Familial History	1,862 (16.8%)
▶ Familial History	387 ( 3.5%)



# Data Preparation: Cancer Cases

## Stratification

- ▶ Census Block Group (1...143)
- ▶ Cancer Type (1...42)
- ▶ Incident Year (1973...2001)
- ▶ 5-Year Age Group (1...18)
- ▶ Sex (M, F)
- ▶ Residential Tenure (unknown, short, long)
- ▶ Familial History for Cancer (unknown, no history, history)



SaTScan Case Input Files

# Data Preparation: Population

- ▶ Partition 1970, 1980, 1990, 2000 Census Data into the Census 2000 Block Groups

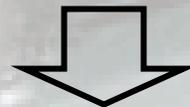
(Census Block Group, 5-Year Age Group, Sex)

- ▶ Calculate the Inter-censal year populations

(Census Block Group, Incident Year, 5-Year Age Group, Sex)

- ▶ Partition for Residential History and Familial History of Cancer

(Census Block Group, Incident Year, 5-Year Age Group, [Sex Residential Tenure & Familial History] )



SaTScan Population Input Files



Population  
Processing  
Macro

# Spatio-Temporal Analysis

## ▶ Standardization

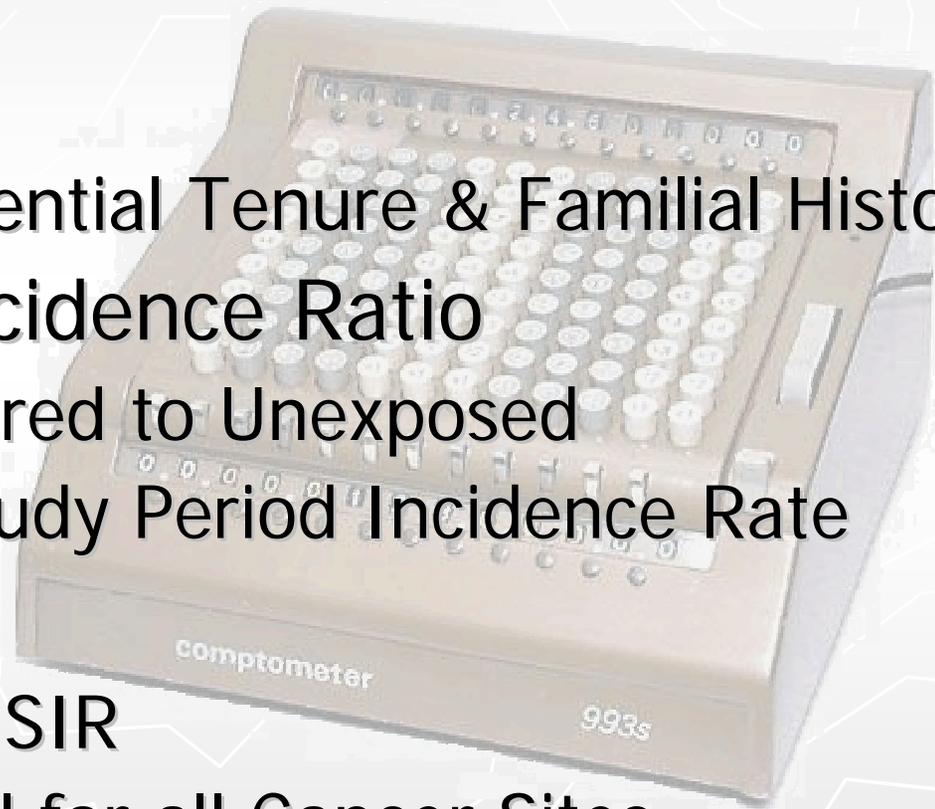
- Age & Sex
- Age, Sex, Residential Tenure & Familial History

## ▶ Standardized Incidence Ratio

- Exposed Compared to Unexposed
- Standardized Study Period Incidence Rate

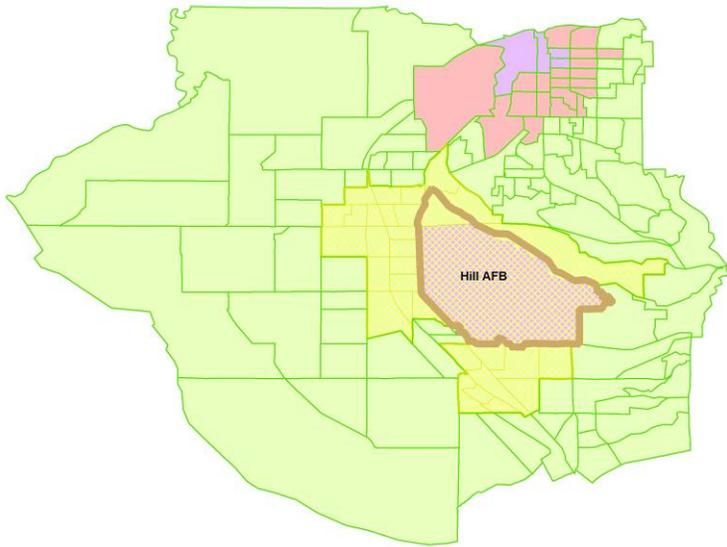
## ▶ SaTScan

- Spatial Only for SIR
- Spatio-Temporal for all Cancer Sites.



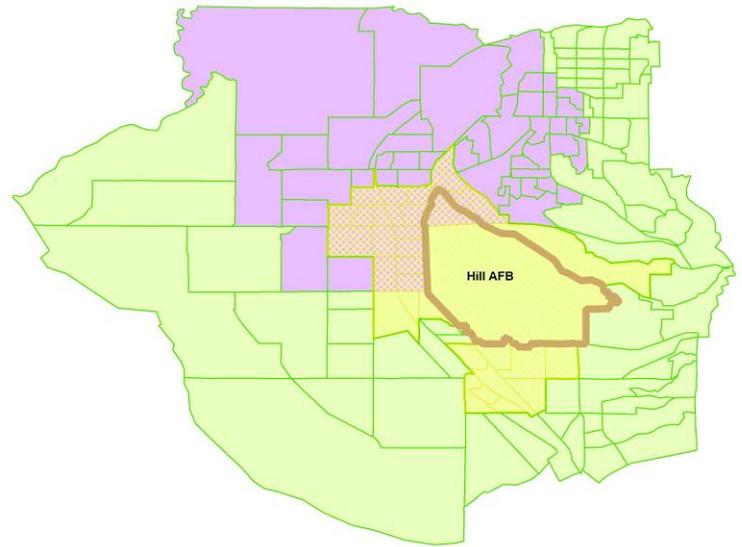
# Standardized Incidence Ratio

Cancer Site	Standardized Incidence Ratio (95% Confidence Intervals)	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Lung and Bronchus	<b>1.30 (1.16-1.45)</b>	<b>1.27 (1.14-1.42)</b>
Kidney and Renal Pelvis	<b>1.31 (1.01-1.66)</b>	<b>1.28 (0.99-1.63)</b>
Eye and Orbit	<b>2.31 (1.35-3.68)</b>	<b>2.08 (1.18-3.40)</b>
Multiple Myeloma	<b>1.41 (1.04-1.86)</b>	<b>1.45 (1.08-1.92)</b>



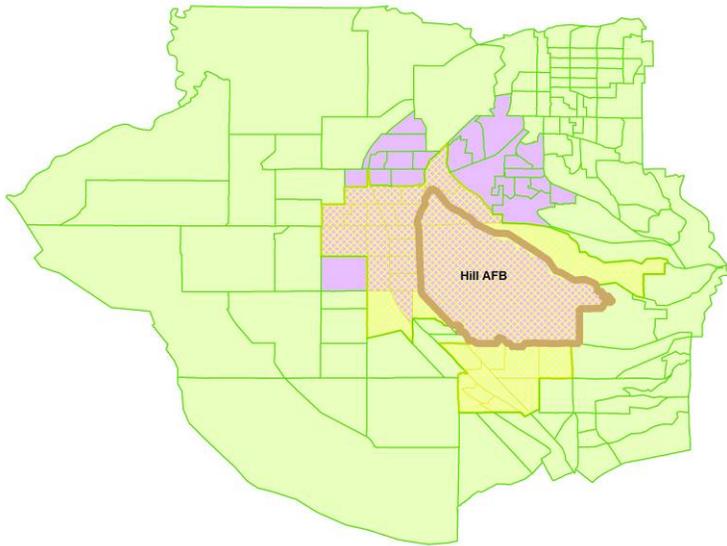
**Census (2000) Block Group Boundaries**  
 Unexposed Population  
 Exposed Population

**SaTScan Results (Spatial Only) for Lung Cancers**  
 Significant when Stratified by:  
 Age, Sex, Residential Tenure & Familial History  
 Age & Sex or Age, Sex, Residential Tenure & Familial History



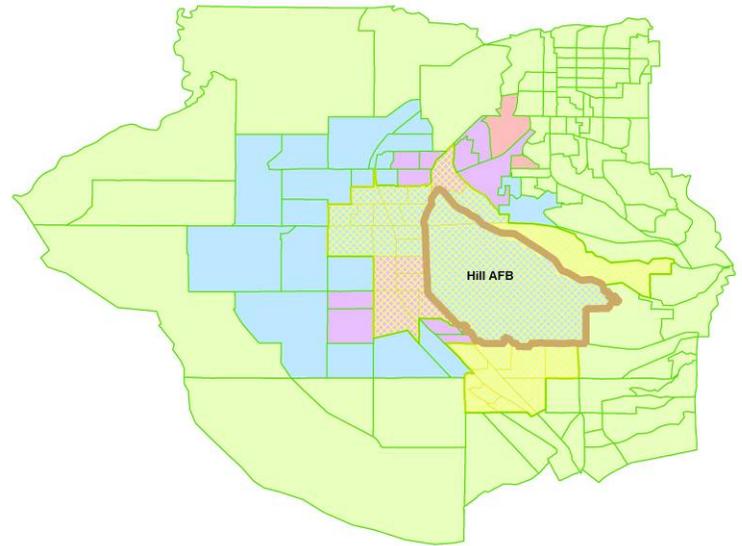
**Census (2000) Block Group Boundaries**  
 Unexposed Population  
 Exposed Population

**SaTScan Results (Spatial Only) for Kidney Cancers**  
 Significant when Stratified by:  
 Age & Sex or Age, Sex, Residential Tenure & Familial History



**Census (2000) Block Group Boundaries**  
 Unexposed Population  
 Exposed Population

**SaTScan Results (Spatial Only) for Eye Cancers**  
 Significant when Stratified by:  
 Age & Sex or Age, Sex, Residential Tenure & Familial History

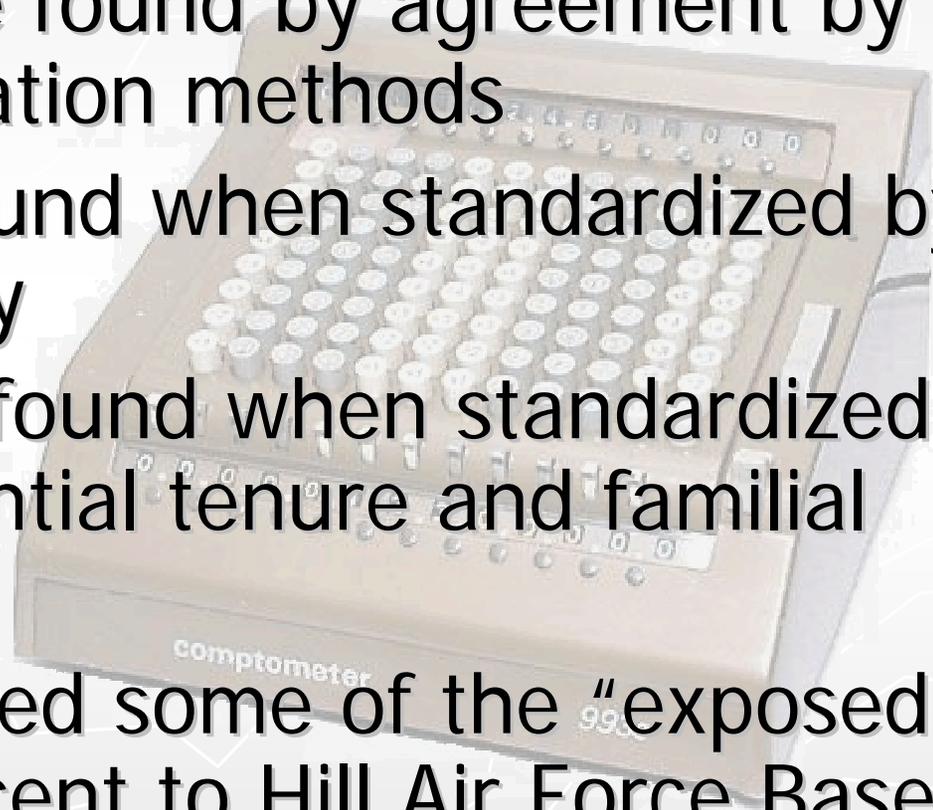


**Census (2000) Block Group Boundaries**  
 Unexposed Population  
 Exposed Population

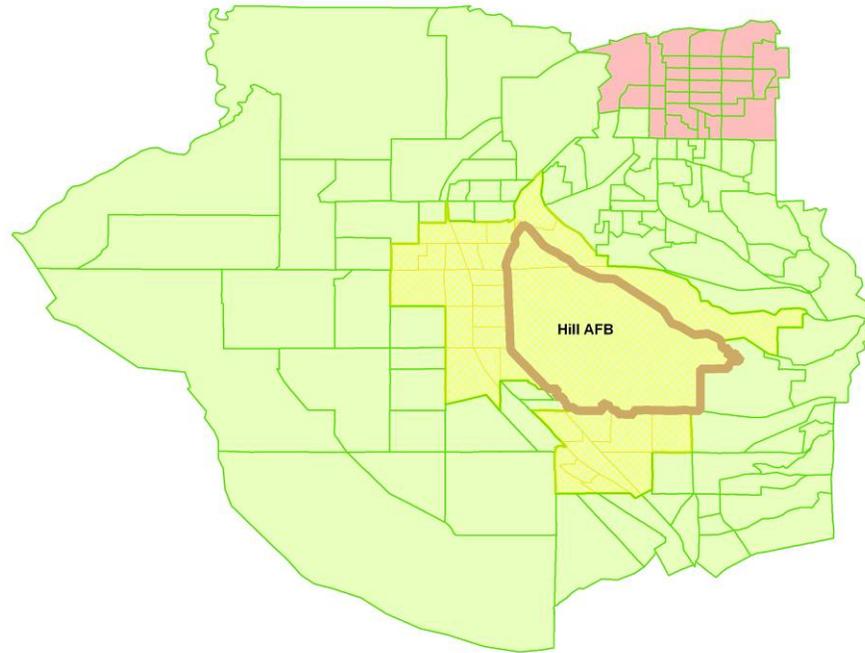
**SaTScan Results (Spatial Only) for Multiple Myeloma**  
 Significant when Stratified by:  
 Age & Sex  
 Age, Sex, Residential Tenure & Familial History  
 Age & Sex or Age, Sex, Residential Tenure & Familial History

# Spatio-Temporal SaTScan Results

- ▶ 11 clusters were found by agreement by both standardization methods
- ▶ 1 cluster was found when standardized by age and sex only
- ▶ 5 clusters were found when standardized by age, sex, residential tenure and familial history
- ▶ 7 clusters included some of the "exposed" population adjacent to Hill Air Force Base



# Oral Cancers



## Census (2000) Block Group Boundaries

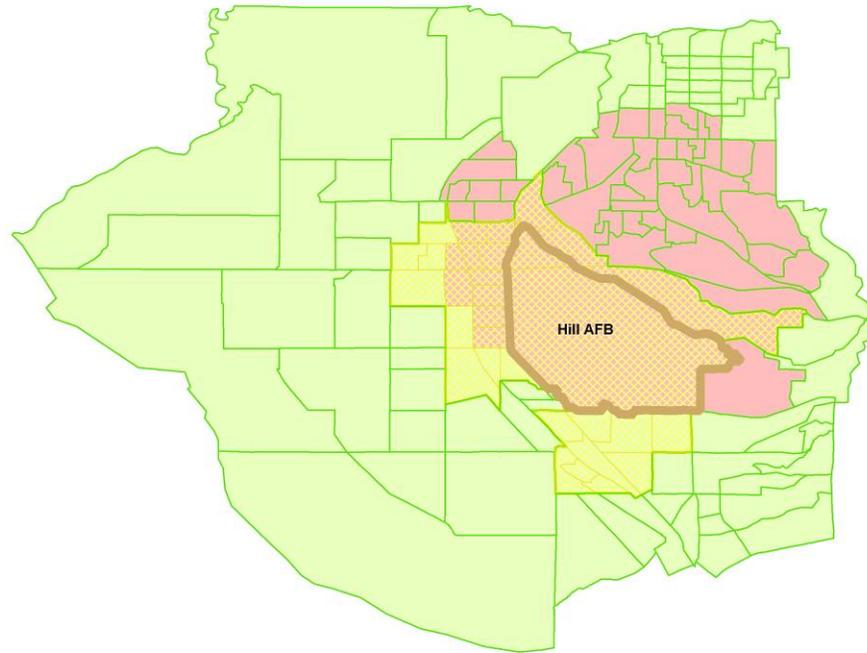
- Unexposed Population
- Exposed Population

## SaTScan Results for Oral Cancers

- Significant when Stratified by:
- Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	288	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	NS	1975 – 1988
Number of Cases in Cluster	NS	59
Standardized Incidence Ratio	NS	2.0
p-Value	0.217	0.025

# Esophageal Cancers



## Census (2000) Block Group Boundaries

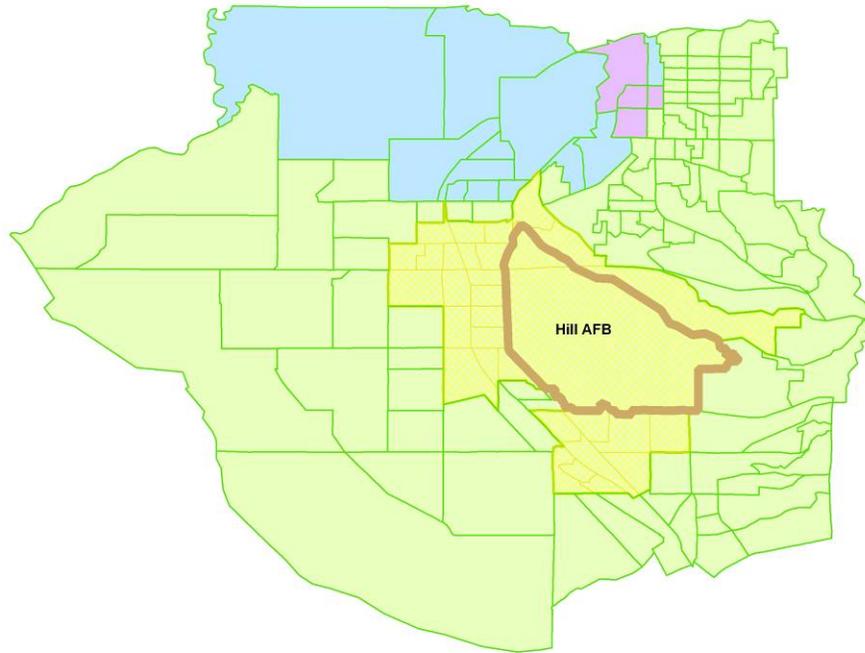
- Unexposed Population
- Exposed Population

## SaTScan Results for Esophageal Cancers

- Significant when Stratified by:
- Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	76	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	NS	1990 – 2000
Number of Cases in Cluster	NS	33
Standardized Incidence Ratio	NS	2.4
p-Value	0.052	0.013

# Colon Cancers



## Census (2000) Block Group Boundaries

- Unexposed Population
- Exposed Population

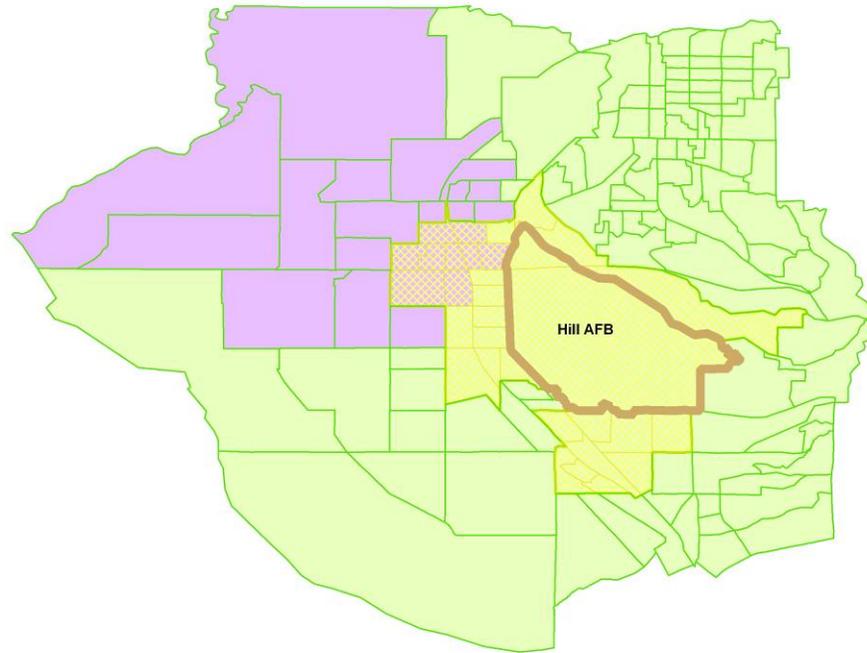
## SaTScan Results for Colon Cancers

### Significant when Stratified by:

- Age & Sex
- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	46	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	1973 – 1983	1973 – 1983
Number of Cases in Cluster	61	30
Standardized Incidence Ratio	2.1	2.9
p-Value	0.018	0.038

# Rectal Cancers



**Census (2000) Block Group Boundaries**

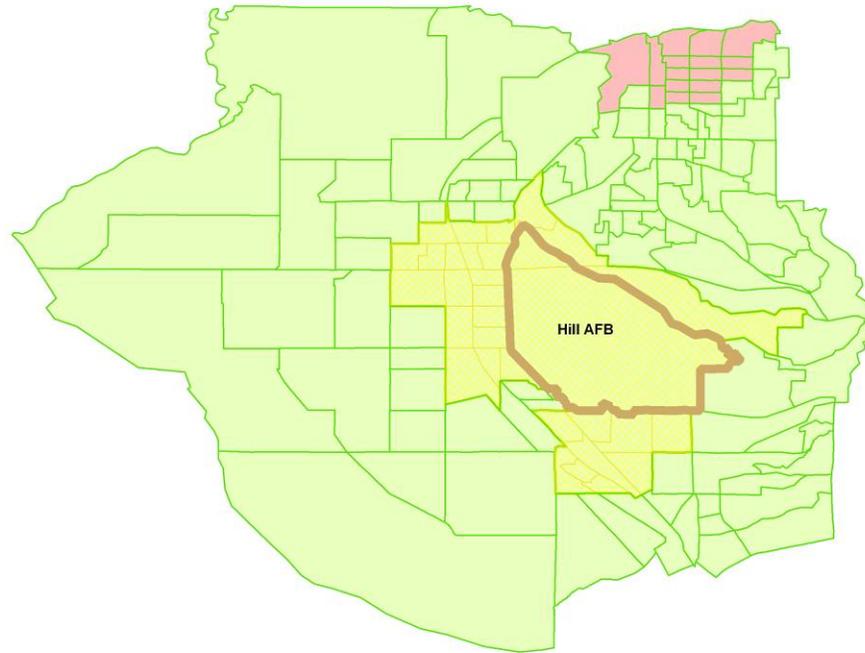
- Unexposed Population
- Exposed Population

**SaTScan Results for Rectal Cancers**

- Significant when Stratified by:
- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	838	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	1993 – 1993	1993 – 1993
Number of Cases in Cluster	13	13
Standardized Incidence Ratio	6.2	6.0
p-Value	0.023	0.028

# Pancreatic Cancers



## Census (2000) Block Group Boundaries

- Unexposed Population
- Exposed Population

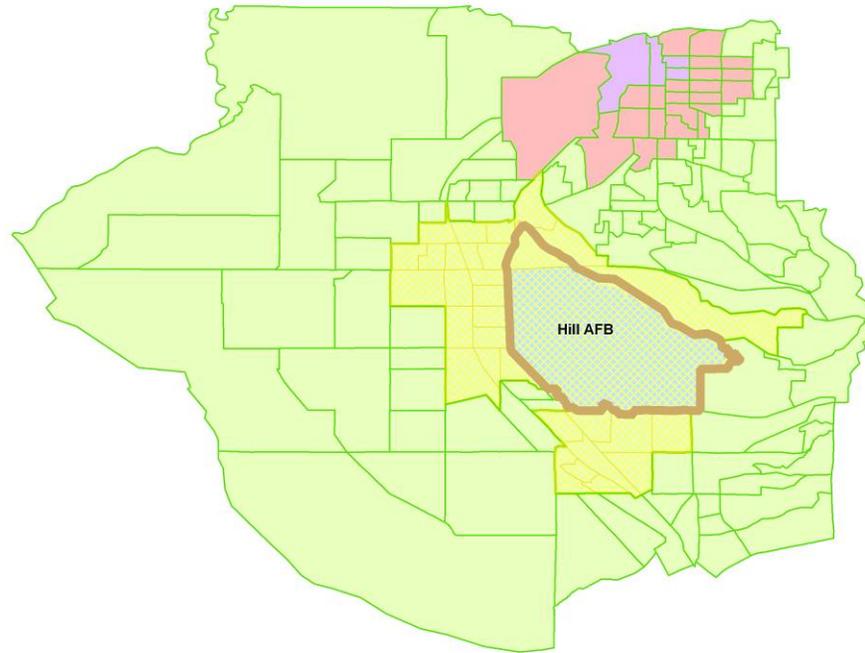
## SaTScan Results for Pancreatic Cancers

### Significant when Stratified by:

- Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	283	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	NS	1975 – 1988
Number of Cases in Cluster	NS	47
Standardized Incidence Ratio	NS	2.5
p-Value	0.057	0.001

# Lung Cancers



### Census (2000) Block Group Boundaries

- Unexposed Population
- Exposed Population

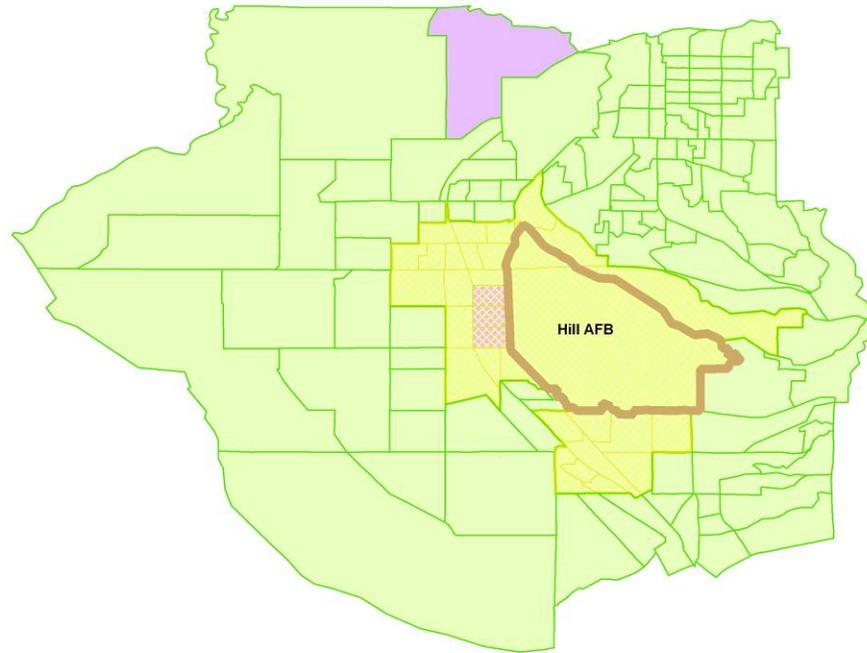
### SaTScan Results for Lung Cancers

#### Significant when Stratified by:

- Age & Sex
- Age, Sex, Residential Tenure & Familial History
- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	1,046	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	1988–2001 / 1989-2001	1988-2001 / NS
Number of Cases in Cluster	51 / 10	166 / NS
Standardized Incidence Ratio	3.9 / 9.7	1/9 / NS
p-Value	<0.001 / 0.011	<0.001 / 0.451

# Other Respiratory System Cancers



**Census (2000) Block Group Boundaries**

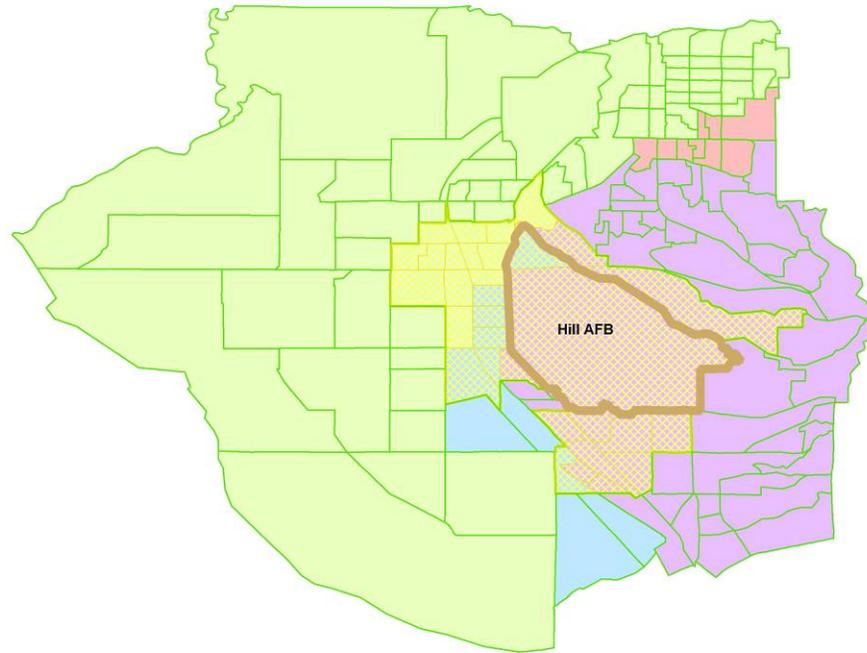
- Unexposed Population
- Exposed Population

**SaTScan Results for Other Respiratory System Cancers**

- Significant when Stratified by:
- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	46	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	1991-1996 / 1987-1990	1991-1996 / 1987-1990
Number of Cases in Cluster	4 / 5	4 / 5
Standardized Incidence Ratio	69.8 / 30.7	73.4 / 31.5
p-Value	0.012 / 0.020	<0.001 / 0.010

# Breast Cancers



## Census (2000) Block Group Boundaries

- Unexposed Population
- Exposed Population

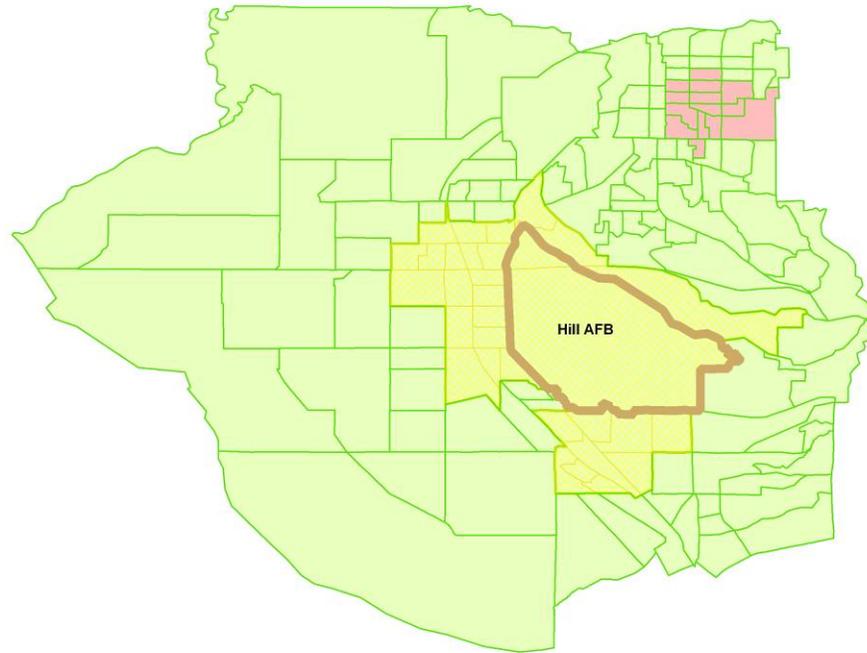
## SaTScan Results for Breast Cancers

### Significant when Stratified by:

- Age & Sex
- Age, Sex, Residential Tenure & Familial History
- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	1,580	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	1993 – 2001	1993 – 2001
Number of Cases in Cluster	387	384
Standardized Incidence Ratio	1.3	1.4
p-Value	0.001	<0.001

# Uteral Cancers



## Census (2000) Block Group Boundaries

- Unexposed Population
- Exposed Population

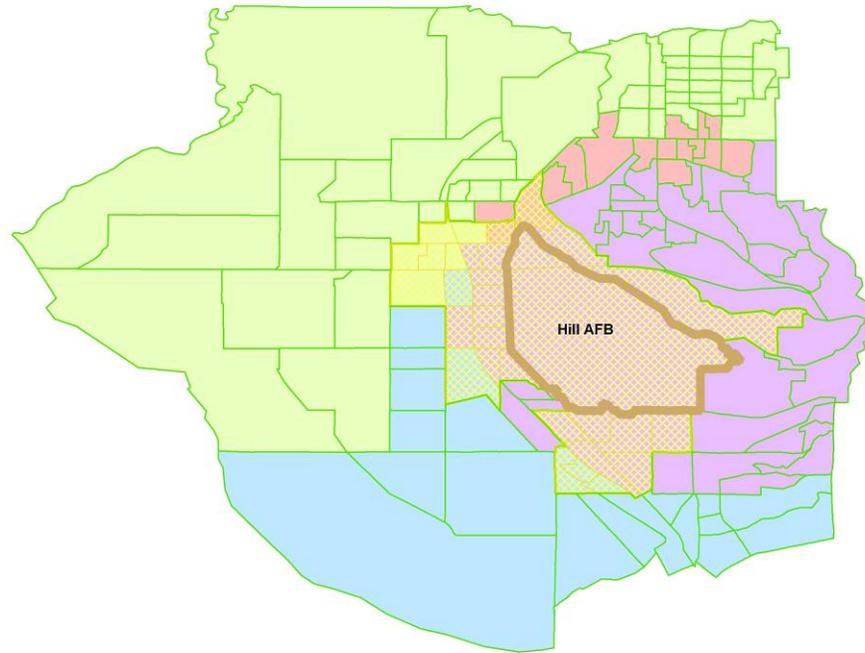
## SaTScan Results for Uteral Cancers

### Significant when Stratified by:

- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	403	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	NS	1973 – 1983
Number of Cases in Cluster	NS	43
Standardized Incidence Ratio	NS	2.4
p-Value	0.161	0.021

# Prostate Cancers



## Census (2000) Block Group Boundaries

- Unexposed Population
- Exposed Population

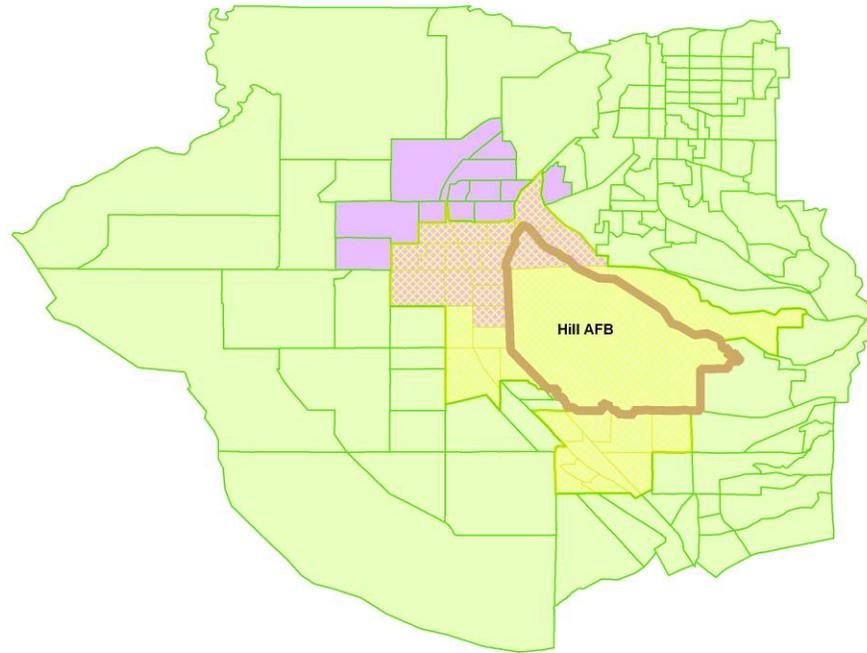
## SaTScan Results for Prostate Cancers

### Significant when Stratified by:

- Age & Sex
- Age, Sex, Residential Tenure & Familial History
- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	1,783	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	1991 – 2001	1991 – 2001
Number of Cases in Cluster	587	562
Standardized Incidence Ratio	1.3	1.5
p-Value	<0.001	<0.001

# Testicular Cancers



## Census (2000) Block Group Boundaries

- Unexposed Population
- Exposed Population

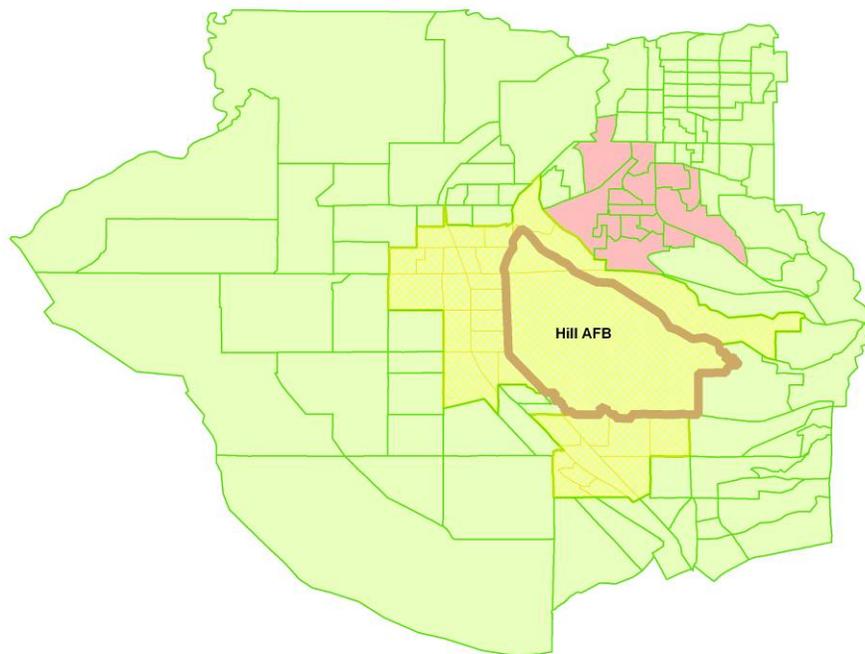
## SaTScan Results for Testicular Cancers

### Significant when Stratified by:

- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	145	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	1991 – 1994	1991 – 1994
Number of Cases in Cluster	17	17
Standardized Incidence Ratio	4.3	4.3
p-Value	0.029	0.030

# Bladder Cancers



## Census (2000) Block Group Boundaries

- Unexposed Population
- Exposed Population

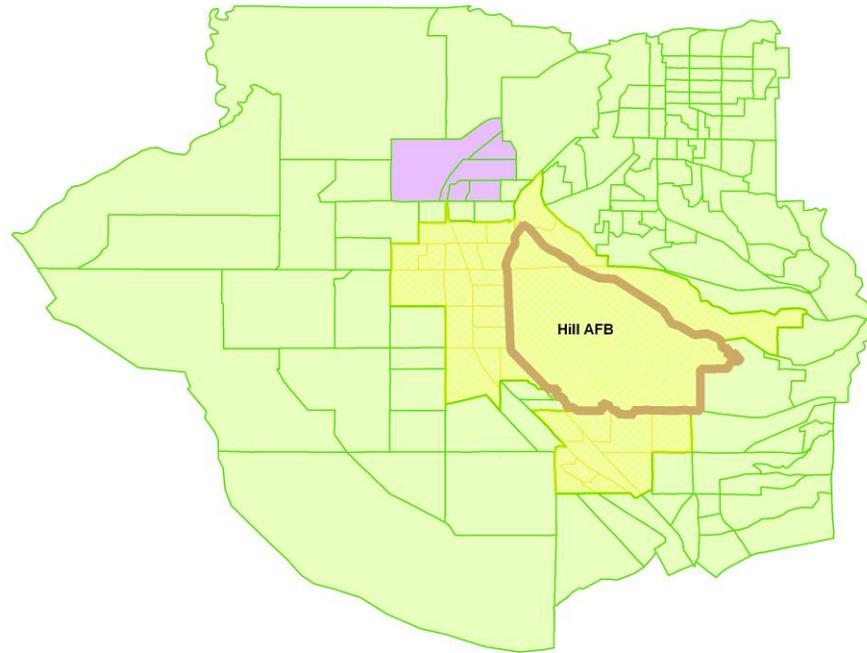
## SaTScan Results for Bladder Cancers

### Significant when Stratified by:

- Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	385	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	NS	1994 – 2000
Number of Cases in Cluster	NS	34
Standardized Incidence Ratio	NS	2.7
p-Value	0.217	0.030

# Other Urinary System Cancers



## Census (2000) Block Group Boundaries

- Unexposed Population
- Exposed Population

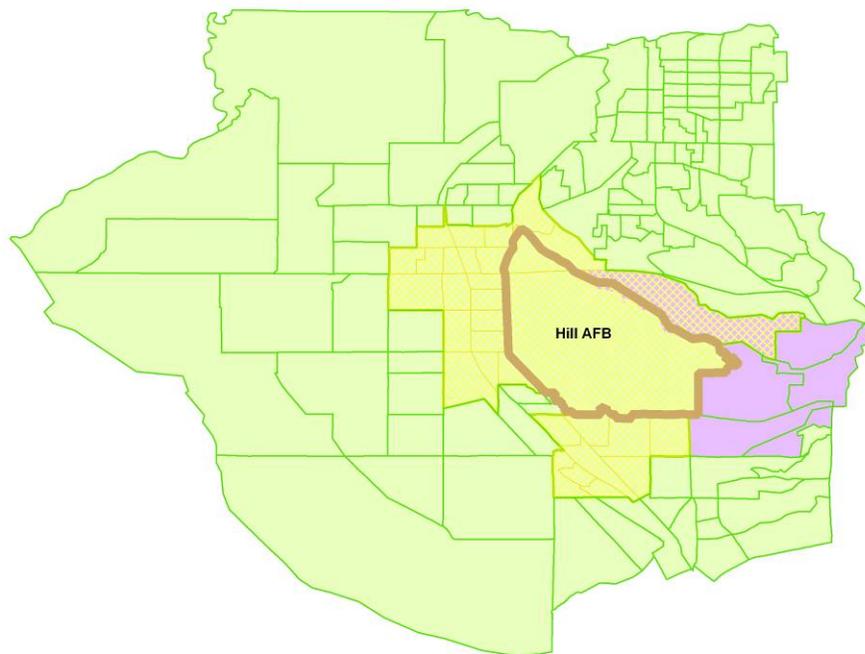
## SaTScan Results for Other Urinary System Cancers

### Significant when Stratified by:

- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	14	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	1991 – 1999	1991 – 1999
Number of Cases in Cluster	5	5
Standardized Incidence Ratio	22.0	24.4
p-Value	0.032	0.022

# Brain Cancers



## Census (2000) Block Group Boundaries

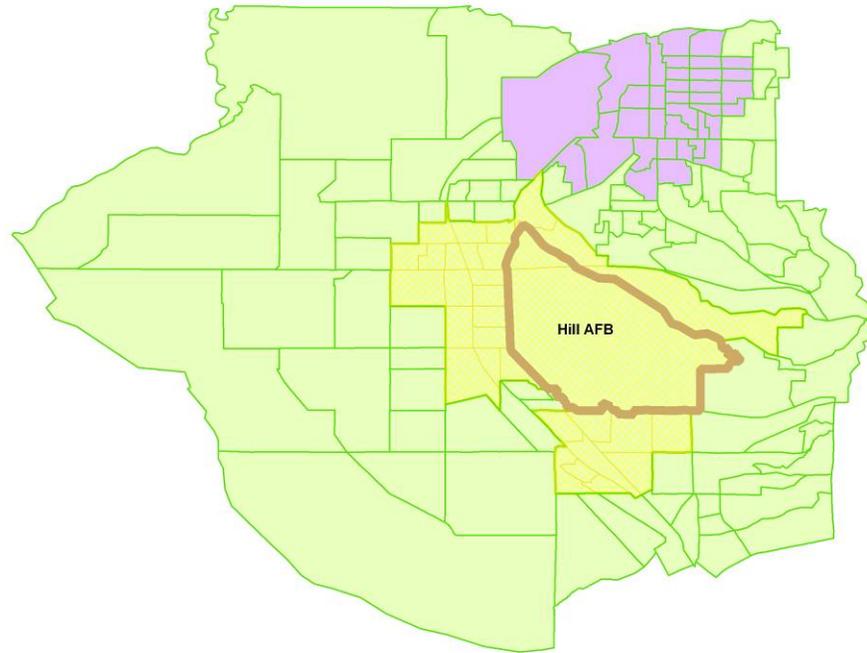
- Unexposed Population
- Exposed Population

## SaTScan Results for Brain Cancers

- Significant when Stratified by:
- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	273	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	1988 – 1999	1988 – 1999
Number of Cases in Cluster	21	21
Standardized Incidence Ratio	3.9	3.8
p-Value	0.012	0.019

# Lymphocytic Leukemia



## Census (2000) Block Group Boundaries

- Unexposed Population
- Exposed Population

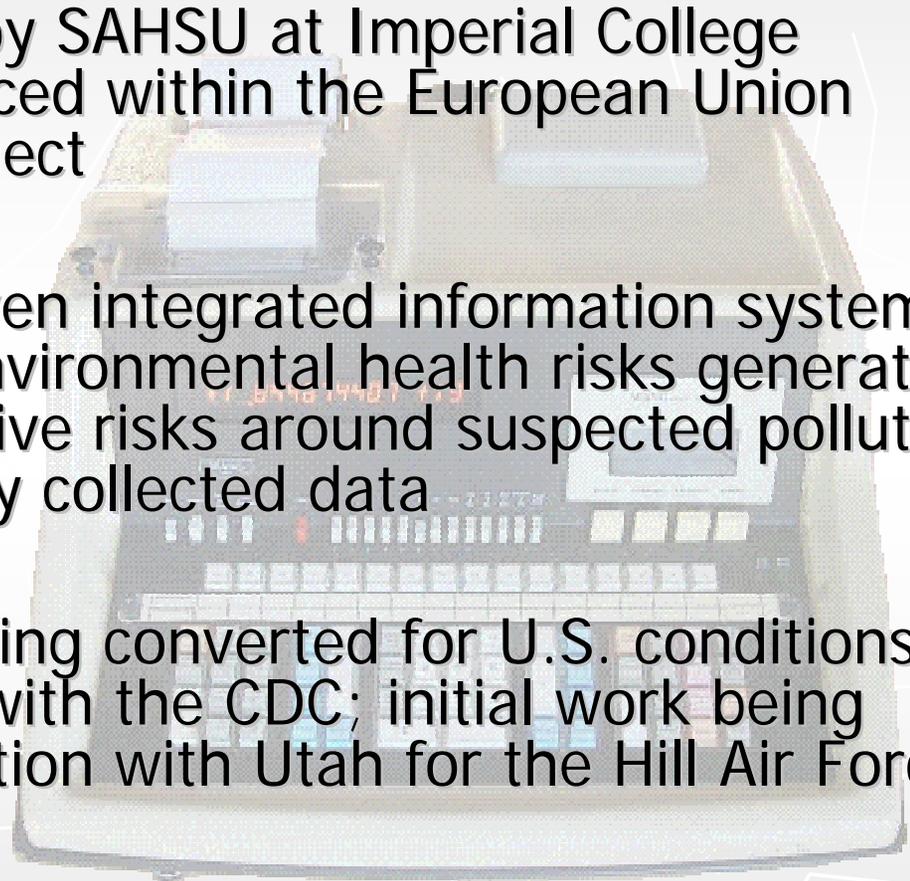
## SaTScan Results for Lymphocytic Leukemia

- Significant when Stratified by:
- Age & Sex or Age, Sex, Residential Tenure & Familial History

Number of Cases in the Study Area	194	
	Age & Sex	Age, Sex, Residential Tenure & Familial History
Cluster Period	1992 – 1993	1992 – 1993
Number of Cases in Cluster	20	20
Standardized Incidence Ratio	5.6	6.2
p-Value	<0.001	<0.001

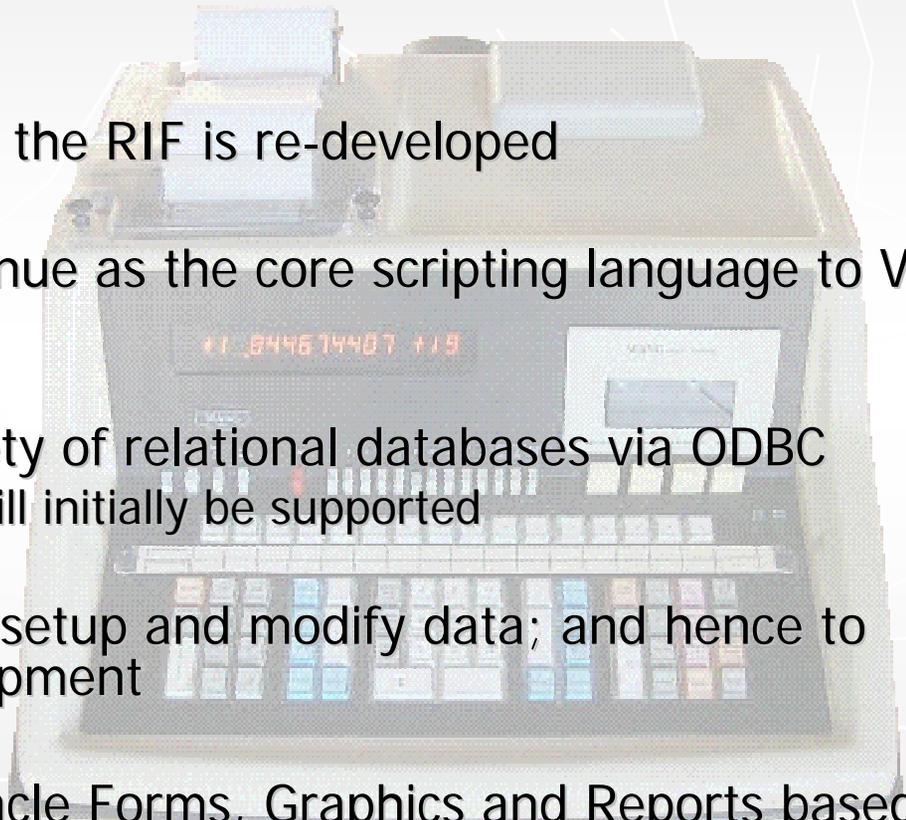
# Rapid Inquiry Facility

- ▶ The RIF is developed by SAHSU at Imperial College London, further enhanced within the European Union funded EUROHEIS project
- ▶ The RIF is a menu-driven integrated information system for rapid assessment of environmental health risks generating disease rates and relative risks around suspected pollution sources, using routinely collected data
- ▶ The RIF is currently being converted for U.S. conditions through collaboration with the CDC; initial work being conducted in collaboration with Utah for the Hill Air Force Base study

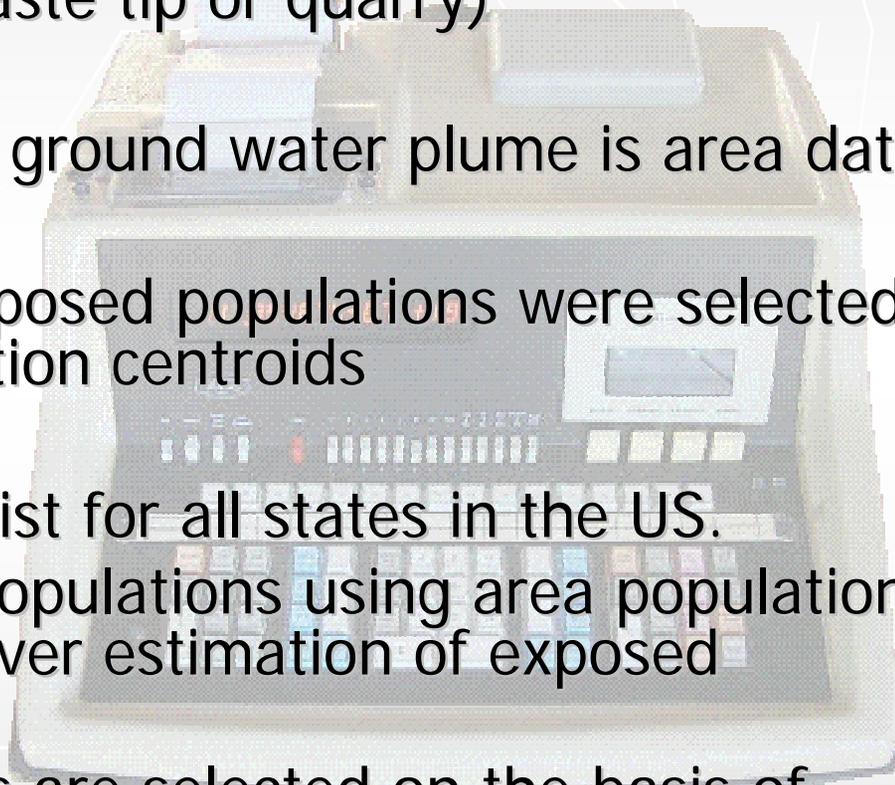


# RIF development

- ▶ The original RIF was developed for Oracle database software and ArcView GIS software
- ▶ To achieve more flexibility the RIF is re-developed
- ▶ To port from ArcView/Avenue as the core scripting language to VB 6/VBA
- ▶ To be able support a variety of relational databases via ODBC
  - Access and Oracle 10g will initially be supported
- ▶ To make it easier to load, setup and modify data; and hence to foster co-operative development
- ▶ To replace the current Oracle Forms, Graphics and Reports based reporting interface with VB 6/VBA reports compatible with modern office tools (e.g. Word, PowerPoint)



# Implementation Issues

- ▶ Risk analysis originally focused on point source pollution data (e.g. a factory, waste tip or quarry)
  - ▶ The TCE contaminated ground water plume is area data
  - ▶ In the UK, potential exposed populations were selected using weighted population centroids
  - ▶ These data may not exist for all states in the US.
    - Selecting exposed populations using area population data could lead to over estimation of exposed populations
    - Exposed populations are selected on the basis of dynamically calculated geographical centroids
- 

# Conclusions

## ▶ Project Purpose

- Demonstration integration of the Utah Cancer Registry and the Utah Population Database with other environmental, geo-spatial and population data
- Improve environmental disease cluster investigations
- Provide a data platform for modification and implementation of the Rapid Inquiry Facility system

## ▶ Cluster Findings



Your Turn

