A Spatiotemporal Analysis of Racial Disparity in the Distribution of Superfund Sites within Santa Clara County, California

by

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To my family who provided me with endless encouragement, comfort, and snacks throughout my endeavors.

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Abbreviations

CA	California
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
EO	Executive Order
EPA	Environmental Protection Agency
GIS	Geographic Information System
GISci	Geographic Information Science
HOLC	Home Owner's Loan Corporation
MAUP	Modifiable Areal Unit Problem
OLEM	Office of Land and Emergency Management
NASA	National Aeronautics and Space Administration
NHGIS	National Historical Geographic Information System
NPL	National Priority List
SCC	Santa Clara County
SEDAC	SocioEconomic Data and Applications Center
SEMS	Superfund Enterprise Management System
SSI	Spatial Sciences Institute
US	United States
USC	University of Southern California

Abstract

Sites listed on the Environmental Protection Agency's National Priority List (NPL) are some of the most polluted or contaminated locations in the United States. Only locations that have been evaluated as posing the greatest widespread and imminent threat to human health and/or the biophysical environment make it onto the NPL, and Santa Clara County (SCC) in California is home to twenty-three of them. Since the creation of the NPL and associated Superfund program in the 1980s, hundreds of studies in the field of environmental justice have provided evidence that the burdens of environmental hazards, like Superfund sites, are not distributed equally across racial, ethnic, or economic groups. Thus, in an effort to better understand the extent of this idea this project seeks to ascertain if a spatial disparity in the distribution of Superfund site locations within SCC exists today and whether post-siting demographic change occurred around sites within the county. This project maps the locations of active and historic Superfund sites in addition to completing a longitudinal, area-weighted analysis of the surrounding communities and study area. By spatiotemporally assessing theories associated with hazardous waste sites and disparities, this project ultimately seeks to provide a clearer understanding of how environmental hazards and disparities can affect and shape the communities in which they are found.

Chapter 1 Introduction

Sites listed on the Environmental Protection Agency's (EPA) National Priority List (NPL) are some of the most polluted or contaminated locations in the entire United States. Colloquially known as Superfund sites, only locations evaluated as posing the greatest widespread and imminent threat to human health and/or the biophysical environment make it onto the NPL. Unbeknownst to many, Santa Clara County (SCC), right in the heart of California's Silicon Valley, is home to twenty-three NPL sites—more than any other county in the United States (US EPA OLEM 2021).

Since the inception of the NPL and associated Superfund site program in the 1980s, hundreds of papers have been published within the field of environmental justice confirming that the burdens of environmental hazards, like Superfund sites, are not distributed equally across racial, ethnic, or economic groups (Bullard 1983; UCC 1987; Mohai & Saha 2015). The detrimental health and quality of life caused by contaminants leaching or being emitted from these sites is concerning on its own (citation). However, the additional factor that certain groups of people are disproportionally burdened by these environmental hazards has spurred many to search for explanations as to why and how these disparities came to be in order to remedy and eliminate environmental injustices.

Studies point to two main theoretical processes through which environmental disparities can occur— disparate siting and post-siting demographic change. With both processes, historical, systemic factors and practices in-part contribute to the proliferation and persistence of environmental disparities. To better understand the extent of these theories, this project utilizes census tract level census data to complete a longitudinal, area-weighted analysis of the SCC communities around NPL sites from 1960-2010. Through this spatiotemporal analysis, this project seeks to ascertain if a spatial disparity in the distribution of Superfund site locations within SCC exists today and whether demographic change occurred around sites within the county.

1.1. The National Priority List and Superfund Site Program

The NPL was created by the U.S. Environmental Protection Agency (EPA) after the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) was passed in 1980 (US EPA, OLEM 2015a). Through CERCLA, polluted sites across the United States were documented and evaluated by the EPA to ascertain how dangerous they were to surrounding populations and ecosystems. The sites which posed the greatest widespread, imminent threat to human health and/or the environment were added to the NPL (US EPA, OLEM 2015b). Once listed on the NPL these sites— also referred to as Superfund sites— are further assessed, have remediation plans created for them, be thoroughly cleaned, and finally undergo long-term monitoring (US EPA, OLEM 2015c.)

On initial inspection, CERCLA and establishment of the NPL seem to be wholly positive measures taken by the U.S. federal government to safeguard *all* its citizens from environmental hazards promptly. However, after these measures were enacted, two pivotal studies published by Bullard in 1983 and the United Church of Christ in 1987 presented evidence of environmental racism, spurred by or in part contributed to by the country's systemic practices and issues. Since then, hundreds of subsequent studies have confirmed that environmental hazards are not distributed equally across racial, ethnic, or economic groups as well as that historical, systemic factors and practices have contributed to disparities existing today (Mohai and Bryant 1992; Lester et al. 2001; Ringquist 2005; Anderton, Oaks, and Egan 1997; O'Neil 2007).

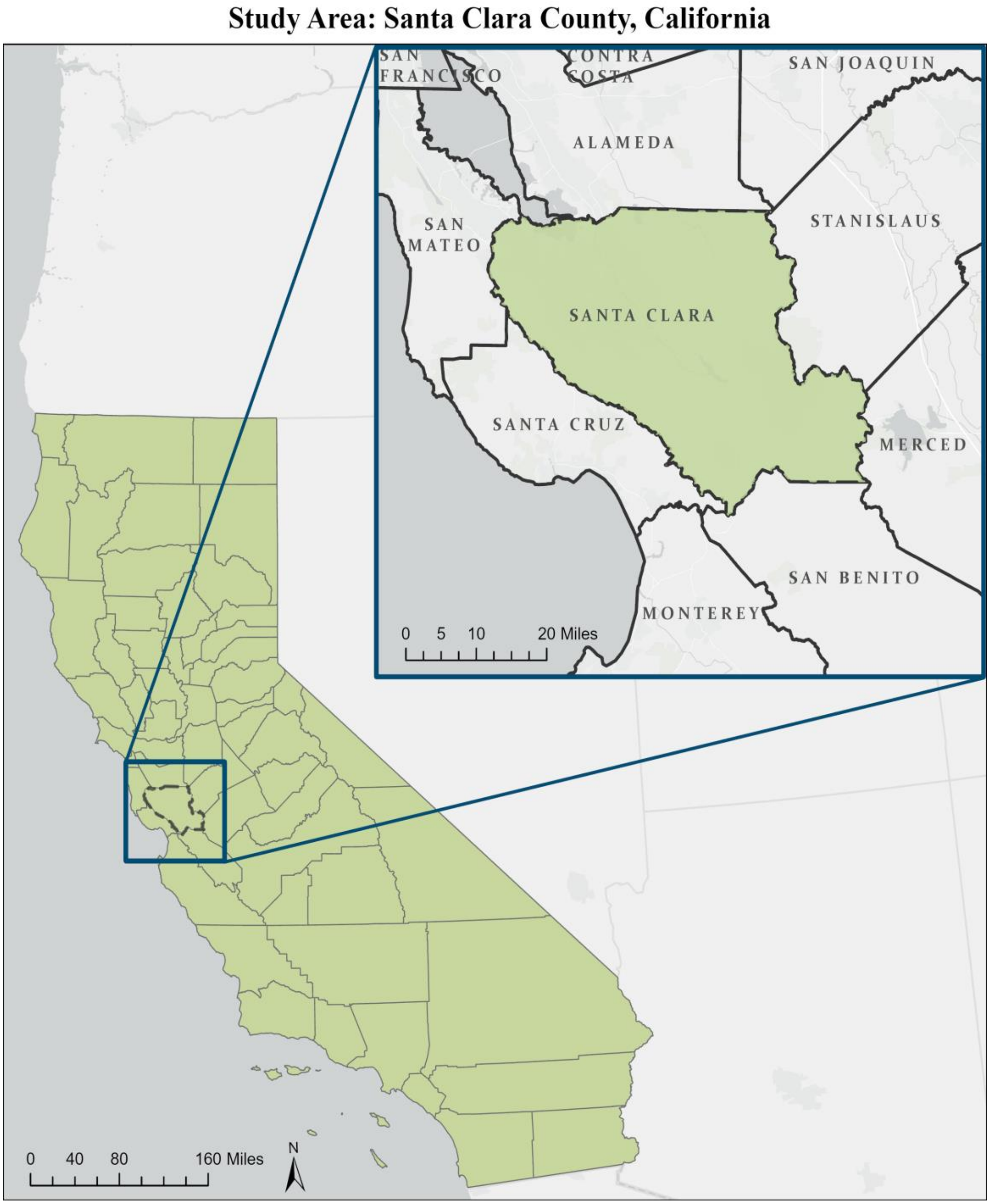

Figure 1 Map of Santa Clara County, California

1.2. Study Area: Santa Clara County, California

Prior to the Fortune-50 companies and start-up incubators, the majority of land in what is now Santa Clara County (SCC) was primarily used for agricultural purposes (City of Santa Clara 2021). Starting around the 1940s, industry shifted towards industrial manufacturing. By the

1950s, the area was known for being a major silicon transistor manufacturing hub. The county's embrace of and reliance on this particular industry during the mid-twentieth century earned the general region its now widely recognized nickname of "Silicon Valley." While the county's current identity as a "global tech-hub" was built upon its legacy of industrial manufacturing in the region, this same legacy paved the way for SCC becoming home to more active, polluted, and contaminated sites than any other county in the entire United States. Of the 1,322 highly polluted or contaminated sites on the National Priority List (NPL) as of 2021, twenty-three are located in SCC (US EPA 2021).

Santa Clara encompasses approximately 1,300 square miles of land and is situated in the South Bay area of Northern California (Figure 1) (County of Santa Clara 2016). As of 2020, SCC is the sixth most populated county in the state with over 1.9 million residents is the 5th fastest-growing county in California with its population seeing an 8.7% increase from 2010 to 2020 (United States Census Bureau 2021a). Population wise the county is dense and diverse with approximately 1,499 people per square mile and a 70.1% on the Census' Diversity Index ranking 8th in the state and 37th in the county (out of 58 CA counties and 3,143 US counties) (United States Census Bureau 2021b).

1.2.1. SCC Superfund Sites

Since 1980, twenty-three superfund sites have been identified in SCC and added to the NPL, but only two of them (Intel Corp. - Santa Clara III and Jasco Chemical Corp.) have successfully met the EPA's remediation criteria and been subsequently removed or "delisted" from the NPL (US EPA 2021). Notably, all of the county's site entries on the NPL are still considered active Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) sites due to ongoing remediation or monitoring (US EPA 2021).

While the county's active CERCLIS sites are the focus of this research, it is important to note that there are other sites in the study area with "known or potential contamination" along with facilities which are permitted to "treat, store, or dispose of hazardous waste" (EnviroStor 2021). Specifically, of the twenty-three sites listed, the majority are categorized as "manufacturing/ processing/ maintenance" (Table 1 and Appendix B). The earliest Superfund sites in SCC are Moffett Field and Lorentz Barrel and Drum Co., built in 1933 and 1946 respectively, while the remaining 21 superfund sites were built after 1950 (US EPA 2021).

Site Type	**Count**
Manufacturing/Processing/Maintenance	19
Waste Management	1
Recycling	1
Other	2
Grand Total	**23**

Table 1 SCC NPL Site by Type (Source: US EPA 2021)

1.3. Objectives and Methods Overview

This study's two main objectives are to determine if there is a disparity in the distribution of Superfund sites and how SCC's demographics have changed across time. Based on similar studies and key papers highlighted in Chapter 2, the demographic/racial composition of populations living closest to Superfund sites is not expected to be proportionate with the demographics of SCC as a whole. Therefore, to ascertain the validity and extent of the study's main objectives, this project mapped the locations of active and historic Superfund sites, completed an area-weighted analysis of the sites' surrounding communities and study area, and calculated the percent change in demographic composition between years.

1.4. Thesis Organization

Chapter 1 touched upon the main topic of this project along with its goals, study area, and scope. Chapter 2 discusses the background research on topics that informed this project. The findings and methods laid out in those works, assisted in the selection of the area-weighted approach that is used for this project in addition to the project's scope. Chapter 3 details the methodology as to the study was conducted. It describes the scope of the project, which sources were used, the attributes associated with important datasets, and the steps that have or will need to be taken for each portion of the spatial analysis. Chapter 4 explains the project's results and discusses whether the results align with the hypothesis. Chapter 5 discusses the significance of the analysis' results, along with limitations of the study, and avenues for further research.

Chapter 2 Related Work

In the 1980s, some of the first papers presenting evidence that ethnic, racial, and economic minority groups experienced pollution and environmental hazard exposure more often than their white or more affluent counterparts within the United States were published (Bullard 1983; UCC 1987). These seminal works gave rise to the field of disparity and environmental justice research and hundreds of subsequent studies have been published to date. Since then, numerous systematic reviews on this body of work have confirmed that environmental risk is not distributed equally across racial, ethnic, or economic groups (Mohai and Bryant 1992; Lester et al. 2001; Ringquist 2005). The following sections review related research exploring how environmental disparities come to be, why the risks associated with environmental hazards have affected certain communities disproportionately, and what some of the conceptual or procedural challenges associated with this research are.

2.1. Quantifying and Measuring Disparities

The exact definitions of inequalities, inequities, and disparities have greatly changed over the years, and the parameters for qualifying what factors or actions play into them are continually evolving. As a result, there is a subset of research which specifically evaluates the variation in definitions and indicators, or measures used for these interrelated groups of terms.

The lack of a clear consensus on how exactly the aforementioned concepts manifest makes the objective of conclusively quantifying their presence and consequences complex. One systematic review identified six different measures of structural racism - “residential neighborhood/housing, perceived racism in social institutions, socioeconomic status, criminal justice, immigration and border enforcement, political participation, and workplace environment” from just 20 articles meeting fairly limiting inclusion criteria (Groos et al. 2018).

Notably, the study limited its scope to only articles that were quantitative, specifically evaluated the concept in association with a health outcome, and explicitly mentioned the terms institutional, institutionalized, structural, or systemic racism within the title or abstract.

Another article assessed how conclusions drawn from several environmental studies varied considerably based on what definition of environmental inequality was being employed (Downey 2007). Using just five definitions, the author then assessed eight studies and explained how conclusions drawn from each study varied significantly depending on the definition used. These articles highlight the complex nature of this topic and group of concepts by demonstrating how critical chosen definitions and measures are within fields evaluating justice and inequality. In addition to the complexities and pitfalls of working on research that utilizes such qualitative and contextually driven data. The complex nature of this subject matter is further supported when accounting for the conceptual and methodological challenges associated with spatial data and analysis in this field.

2.2. Effects of Historic Practices

Historic practices influenced the socioeconomic and physical make-up of many neighborhoods and cities in the United States. Numerous studies have highlighted a relationship between previously redlined neighborhoods, lower home values, and increased proximity to undesirable land uses such as waste sites. Alternatively, there are systematic and structural practices that many today would view positively due to their original intent of increasing equality and equity. One such example is the growth of public environmental concern and recognition of pollutants and hazards as a national issue that was also fraught with disparity. This movement brought about programs and legislation aimed at specifically mitigating the disparate harm those contaminants could cause, but studies have shown that these “positive” practices ultimately did little or nothing in that regard (O'Neil 2007; Murphy-Green and Leip 2002). The impacts historic practices had upon people and places across various sectors within the US is hard to refute, but not necessarily easy to quantify and validate with complete certainty.

2.2.1. Redlining

Researchers studying areas where redlining occurred have provided evidence of the practice's ongoing influence even over 80 years later (Donovan and Fischer 2020). Several studies have shown a relationship between comparatively lower property values than average for a region and being located within a historically, redlined neighborhood as ranked by the Home Owner's Loan Corporation (HOLC) (Appel and Nickerson 2016; Charles 2018). For example, one study states that median home values within a historically redlined Los Angeles neighborhood were only 7.2% higher than prices during previous housing market booms while median values in historically high ranking HOLC neighborhoods was 45.6% higher (Kau and Munneke 2019; Mikhitarian 2018). Additionally, there are several studies highlighting a relationship between redlined neighborhoods and increased proximity to superfund, brownfield, or toxic waste disposal sites (Bullard 1983; Bullard et al. 2007; Maranville, Ting, and Zhang 2009; Moxley and Fischer 2020).

2.2.2. Executive Order 12898

Issued in 1994 by President Bill Clinton, Executive Order (EO) 12898 requires federal agencies to ensure that environmental justice in minority and low-income populations is central to their programs and policies (US EPA 2013). Despite its enactment, a socio-economic and race driven disparity in the designation, listing, and remediation of highly hazardous sites as Superfund sites on the NPL still seems to persist at all stages of the process (Daley and Layton 2004; O'Neil 2007).

One such study supporting this conclusion is an event history analysis evaluating Executive Order 12898's impact at addressing concerns regarding the Superfund program's equitability. Specifically assessing siting step of the process, the study found that sites discovered after the executive order had a smaller chance of being added to the Superfund list if located in areas with "marginalized and poor populations" (O'Neil 2007). This aligns with Daley and Layton's (2004) study exploring why some sites would be more likely to be remediated through survival analysis. One of their findings indicated remedial action is more likely to occur when political oversight is present, which is notable because marginalized and poor populations tend to be overlooked in favor of areas and people with more political "importance" or weight to leverage (Daley and Layton 2004).

2.3. Spatial Spillover and Spatial Scale

Many studies examine how a neighborhood's features can affect social, economic, and health outcomes using spatial data and analysis, but fail to adequately consider whether the aggregation method or type of geographic unit being used is appropriate for the outcome being assessed (Root 2012). Since a study's chosen spatial scale and boundaries directly impacts the precision, accuracy, and significance of the analysis and conclusions there is also an entire subset of research focused on assessing the methodological appropriateness of chosen aggregation methods as they relate to the modifiable areal unit problem (MAUP) and effects of spatial spillover (Fisher, Kelly, and Room 2006; Jelinski and Wu 1996; Dark and Bram 2007).

The use of area-based measures of neighborhood or population characteristics that are solely derived from enumeration units can lead to the underestimation of a factor's effect upon an area or people (Root 2012; Oka and Wong 2016). This underestimation occurs because the boundaries of enumeration units, such as census tracts, are artificial demarcations upon geographic space. In the field of environmental justice, these enumeration unit boundaries are arbitrary as they do not realistically reflect the modern and historic effects of social/political practices and influences or the behaviors of a population when it comes to assessing exposure to a pollutant/hazardous substance (Oka and Wong 2016).

2.4. Modeling Populations and Hazards Longitudinally

Analyzing temporal patterns can necessitate the aggregation of data from a few years to several decades and aggregating socio-economic/demographic data spanning decades can be challenging due to the continually changing factors comprising and influencing this data. This challenge’s complexity is further compounded when attempting to model and examine the causes of environmental disparities which had only started being explored in the late 1970s within the US. Much of the existing, quantitative research on this topic are cross-section/snapshot studies which look at a hazardous site and the study population's characteristics during just one point in time. However, longitudinal analyses looking at the demographic makeup of an environmentally hazardous site before and after it is built/recognized are necessary to fully understand how or why disparate site distributions came to be (Mohai and Saha 2015).

Existing, quantitative environmental justice studies have typically used a “unit-hazard coincidence” or “distance-based” approach when examining the effect of a hazardous source on different groups within a study area (Mohai and Saha 2015). The unit-hazard coincidence method was used by earlier quantitative studies in the field (Mohai and Saha 2006; Chakraborty et al. 2011). This approach compares the demographic characteristics of a geographic unit (such as a county or zip-code area) that has a hazard located within its boundaries against units that do not. These units’ relative distances from the exact location of a hazard are disregarded and they are referred to as “host” and “non-host” units, respectively. Conversely, distance-based methods account for the precise location of a hazard by aggregating units/their demographic characteristics within a certain distance from the hazard together. This method of grouping is also known as the areal containment or appropriation method and can be utilized to further specify exactly how much of a unit's population should be included within a grouping.

Chapter 3 Methods

This study aims to determine if there is a spatial disparity in the distribution of Superfund site locations within Santa Clara County (SCC) and explore whether these sites affected the demographic composition of their surrounding communities. Based on similar studies and key papers highlighted in the previous chapter, the demographic, racial composition of populations living closest to Superfund sites is not expected to proportionally follow the demographic composition presented by SCC as a whole. Therefore, to ascertain the validity and extent of the aforementioned objectives, this project will map the locations of active and historic Superfund sites in addition to completing a longitudinal, area-weighted, location quotient analysis of the surrounding communities and entire study area. Figure 2 outlines the general research workflow for the earliest project stages while subsequent sections of this chapter discuss later stages such as project scope, data sources, data preparation, area-weighting, and location quotient methods ultimately chosen for this project.

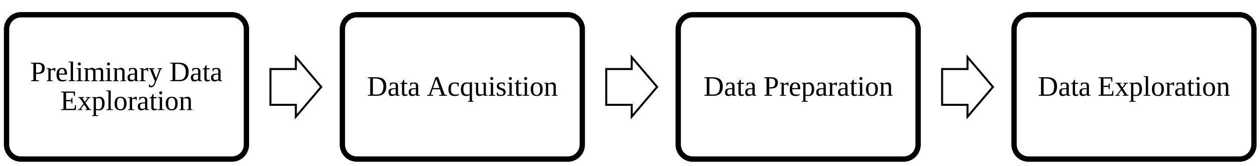

Figure 2 Summary of Early Project Workflow Stages

3.1. Data Scope and Preparation

This project utilizes spatial and categorical data derived from authoritative sources such as the Environmental Protection Agency and United States Census Bureau. The project's spatial scope is limited to Santa Clara County (SCC), California which was discussed in more detail within Chapter 1. Regarding the project's temporal scope, the preliminary data exploration step was critical because understanding what historic demographic and geographic data was available for SCC consequently shaped the project's scope and limitations. Table 2 provides details on all the datasets and sources that were utilized during this project's process. Of the data presented in Table 2, the most critical datasets are "Superfund Sites" and any sets sourced from IPUMS National Historical Geographic Information System (NHGIS). These sources will be further discussed in dedicated sections of this chapter.

3.1.1. Temporal Scope

The temporal scope for the project spans from 1930-2010, however the demographic analysis will only utilize data from 1960-2010 since population counts at the census tract level prior to 1960 were not readily available. The data pulled from IPUMS NHGIS for 1950-2010 would hypothetically be sufficient to complete both main goals mentioned earlier this chapter, but 1930 through 1949 is also included in the project's temporal scope. As shown in Figure 3, there are at least two SCC NPL (Superfund) sites that started operating within this block of years and could therefore serve as important, baseline cases for evaluating the project's second, main objective.

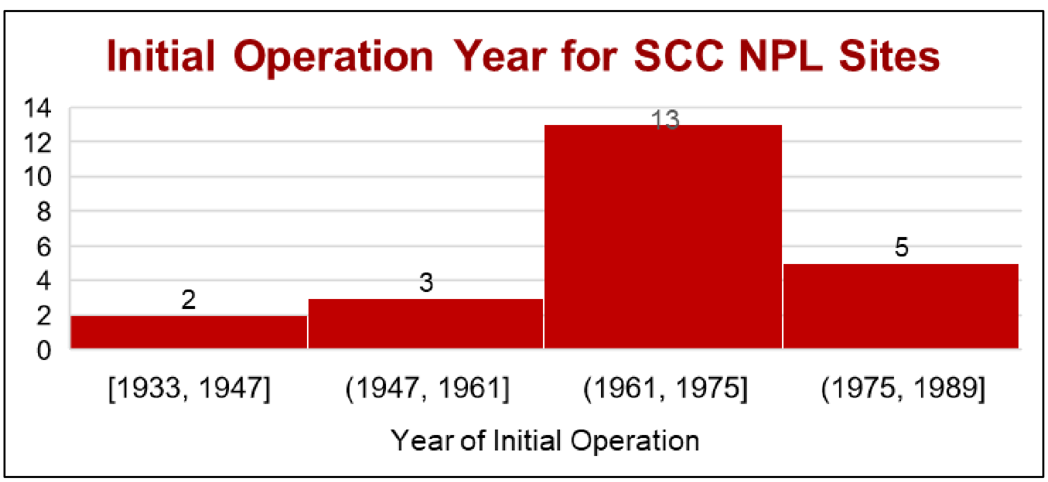

Figure 3 Chart of SCC NPL sites' initial operation years (Source: US EPA 2021)

Table 2 Datasets and Sources

Dataset	**Description**	**Format**	**Data Type**	**Spatial Scale**	**Time Period**	**Source**
Superfund Sites	Location and attributes of superfund sites within SCC study area	.csv	Text and number fields	Sites within SCC	1930-2010	U.S. EPA and the California Department of Toxic Substances Control
	Site Boundaries	.shp	Vector data - polygon	Sites within SCC	2010	NASA's SocioEconomic Data and Applications Center (SEDAC)
Santa Clara Administrative Boundaries	Recent boundaries for county, surrounding counties, and census tract	.shp	Vector data - polygon	SCC and census tracts of various areal sizes	2010	U.S. Census Bureau
	Historic boundaries for county, cities, and census tracts	.shp	Vector data - polygon	City boundaries and census tracts of various areal sizes	1960-2000	IPUMS National Historical Geographic Information System (NHGIS)
Race/Ethnicity	Dataset reporting race/ethnicity population estimates	.csv	Aggregated census tract population estimates – text field	Tracts of various areal sizes	1960-2010	U.S. Census Bureau and IPUMS NHGIS

3.1.2. Demographic Scope

In the US, the concept of race has changed drastically over time and these shifting notions of it are reflected across the US Census. In 2010 there were six race categories available for selection while the 1960 census included just three race categories – white, black, and other (Pratt et al. 2015; Brown 2020). Thus, two demographic grouping methods were utilized to address the inconsistencies present in US Census data aggregated by race – the fully condensed grouping (FCG) with two broad categories, and partially condensed grouping (PCG) with five, less broad categories. For the FCG, White includes individuals who self-identified as “White, alone” while Non-White includes those self-identifying as any group other than “White, alone.” The PCG includes White (White, alone), Black (Black, alone), American Indian/Alaskan Native (AI/AN, alone), Asian (Asian, alone), and Other (Other race, alone; Two or more races).

As an important note, ethnicity was not included in this project’s scope or analyses due to the even greater number of changes in category options this question has undergone across the decennial census surveys when compared to race. Therefore, when a particular race category is referenced or discussed in this project it includes all individuals who have reported/self-identified as that race/race group on their census questionnaires – regardless of what ethnicities they have reported or how they responded to questions regarding Hispanic or Latino origin.

3.1.3. Data Preparation

The majority of data preparation for the project was completed during the secondary data exploration stage. After acquiring all of the necessary data listed in Table 2, basic clean-up was performed on .csv files as needed using Excel. Basic .csv clean-up included deleting any features outside the SCC study area and ensuring that table header/field names did not contain any characters that could prevent the table for importing into ArcGIS Pro properly. Then, all tables and shapefiles were added to ArcGIS Pro.

In ArcGIS Pro several built-in tools were utilized to further prepare and visualize the data. First, the XY Table to Point was used to convert the imported EPA .csv containing the Superfund site attribute information into a point layer. Next, the NHGIS census tract layers for 2010, 2000, 1990, 1980, 1970, and 1960 were joined with their respective NHGIS population tables using the “GISJOIN” field common to all. All shapefiles were then clipped to the SCC study area boundary to streamline the data for faster loading, viewing, processing, and analysis. Finally, all the shapefiles were transformed from their given projections to NAD 1983 (2011) State Plane California III FIPS 0403 (Meters) using the Project tool.

3.2. Superfund Site Data

As discussed in section 1.1.1, twenty-three hazardous waste sites located in SCC have been listed on the NPL since the program’s inception. Of those sites, also commonly referred to as Superfund sites, only two (Intel Corp. - Santa Clara III and Jasco Chemical Corp.) have successfully met the EPA’s remediation criteria and been subsequently removed from the NPL. Notably, all twenty-three of the sites listed on the NPL are still considered active Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) sites due to ongoing remediation or monitoring (US EPA 2021).

3.2.1. Site Attributes

Attribute information for Superfund Sites is available from the EPA website’s various pages and databases and three separate webpages were used to locate necessary site information (US EPA 2021). The “Search Superfund Site Information” webpage allows users to search for active and archived sites within the EPA’s Superfund Enterprise Management System (SEMS) public user database. Users can narrow down the results pulled from the SEMS database by typing in or selecting search criteria information for fields such as Site Name, County, Region, or NPL Status. For this project the search criteria used was as follows – County: Santa Clara, State: California, Region: 9, NPL Status: Proposed, Current, and Deleted NPL Sites. The webpage returned twenty-three sites matching the given search criteria along with the option to download the sites and their associated attributes as a comma separated file (.csv). The .csv contained unique, 12-character EPA IDs for each site along with useful information for each feature like Site Name, City, Street Address, NPL Status, whether the site is ready for specific uses, site CERCLIS status, type, type subcategory, Hazard Ranking System (HRS) score, aliases, and a link to the site's unique EPA profile page.

The .csv downloaded from this initial webpage did not include coordinates, so the "SEMS Search" EPA webpage was then filled out, using similar search criteria, to obtain the coordinates for each of the sites from SEMS. These point coordinates were manually added to the site .csv downloaded from the first webpage using Excel.

The individual site profile pages included in the .csv from the first EPA webpage were next visited to collect important milestone dates for each of the sites. These dates can be found under the "Cleanup Activities" tab on the left side of each profile and by next clicking on the related sub-tab named "Cleanup Progress." Each profile page for the project sites had milestone dates for: Initial Assessment Completed, Proposed to NPL, Finalized on NPL, Remedial Investigation Started, Final Remedy Selected, Remedial Action Started and/or Final Remedial Action Started. These dates were manually copied and pasted from the site profile page into the .csv obtained from the first webpage using Excel. Finally, the Operation Start Year (date) for each site, was pulled from information presented in the “Background” section located on each site’s Superfund Site Profile Home Page and pasted into the site .csv with Excel.

3.2.2. Site Polygons

The polygon boundaries for each Superfund site were available from NASA’s SocioEconomic Data and Applications Center (SEDAC) website. The site polygons for all Superfund sites within the United States was located in a single shapefile in a downloadable folder titled “ATSDR Hazardous Waste Site Polygon Data with CIESIN Modifications, v2 (2010).” For this project, the boundaries of each Superfund site are important to include because their areas vary greatly, with the smallest being approximately .01 square kilometers (5,691.86 square meters) to the largest at roughly 30.52 square kilometers. Each sites’ boundaries also directly affect the area covered by the buffer zone that will be created and used for the area-weighting analysis component.

3.3. Area Weighting

A number of spatial analysis methods were considered for this project, but area-weighting – specifically the area-apportionment method, was chosen for this project after the preliminary data exploration process. Distance-based methods, like area-weighting, account for the precise location of hazards by aggregating the demographic characteristics of geographic units within a certain distance from the hazard together. Area-apportionment goes further by accounting for the proportion of each geographic unit falling within a particular distance of a hazard to determine what proportion of each geographic units’ population is considered as being within the hazard zone.

As previously mentioned, the area-weighting method that will be used for this project is based off the methodology presented in "Locations of licensed and unlicensed cannabis retailers in California: A threat to health equity?" (Unger et al. 2020). There are notable differences between this and the aforementioned paper's study area (state of California vs SCC), topic (cannabis retailers vs superfund sites), and temporal scope (2018 vs 1960-2010). There are also differences in the approaches used for area-weighting specifically such as this project's use of geodesic buffers instead of service areas, decennial census data instead American Community Survey (ACS) data, and the tabulate intersection tool to calculate and associate site buffer/zone data with demographic data.

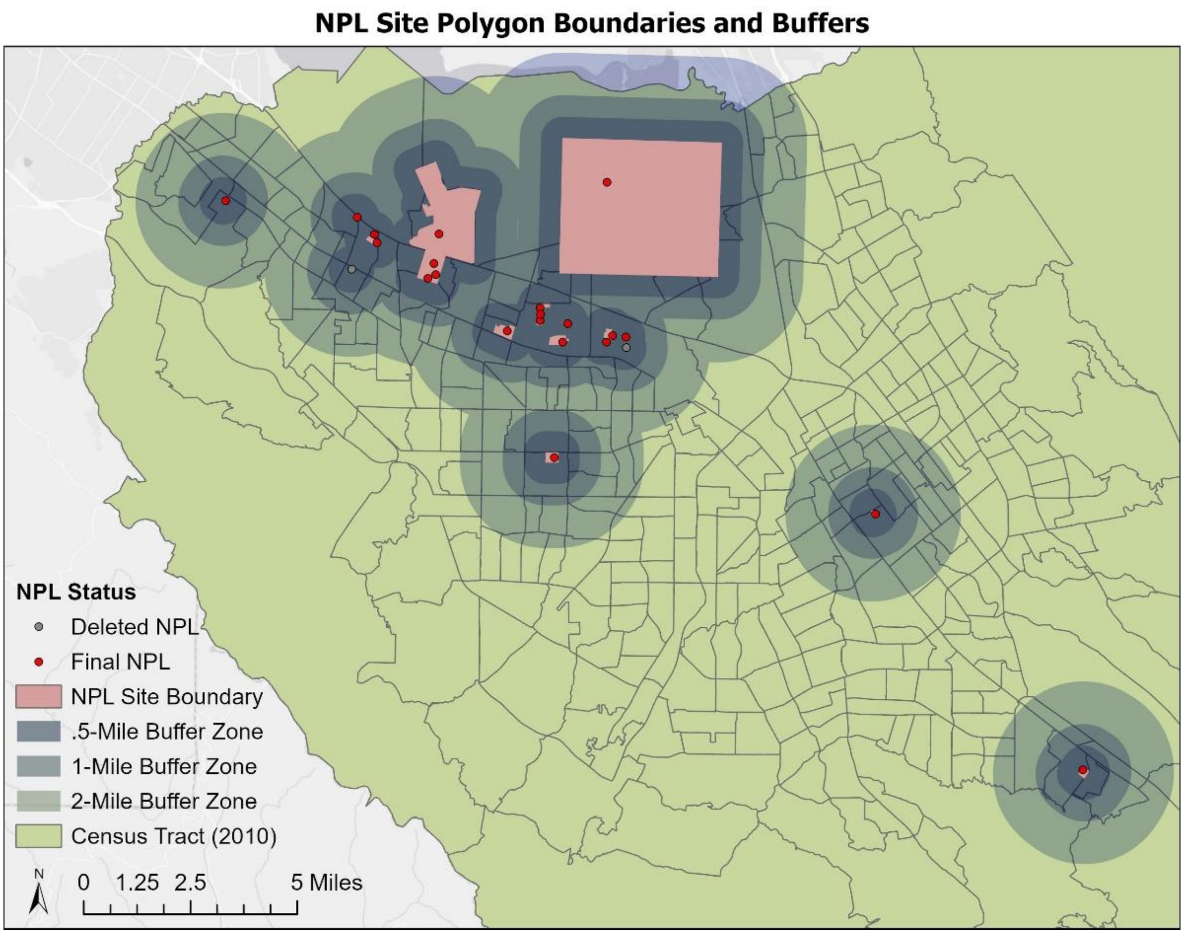

Figure 4 NPL Site Polygons and Buffers

3.3.1. Buffers – Communities Around Sites

During the secondary data exploration stage of the project, half-mile,1-mile, and 2-mile geodesic buffers were created using the ATSDR_NPL polygon layer (Figure 4 and Figure 5) for a total of three buffer polygon layers. The half-mile polygon buffer was used during this stage to test and confirm that the tabulate intersection tool could successfully link the site-zone buffers with project's demographic data and accurately calculate the proportion of the population within a half-mile of each superfund site. During this time, it was decided that the EPA_NPL point buffers, which were also created for testing, would be shelved in favor of the polygon buffers. The point buffers did not realistically account for the variations in boundary size across all the superfund sites which meant that using them for area-weighting would lead to an underestimation of people and census tracts that have been affected by the sites.

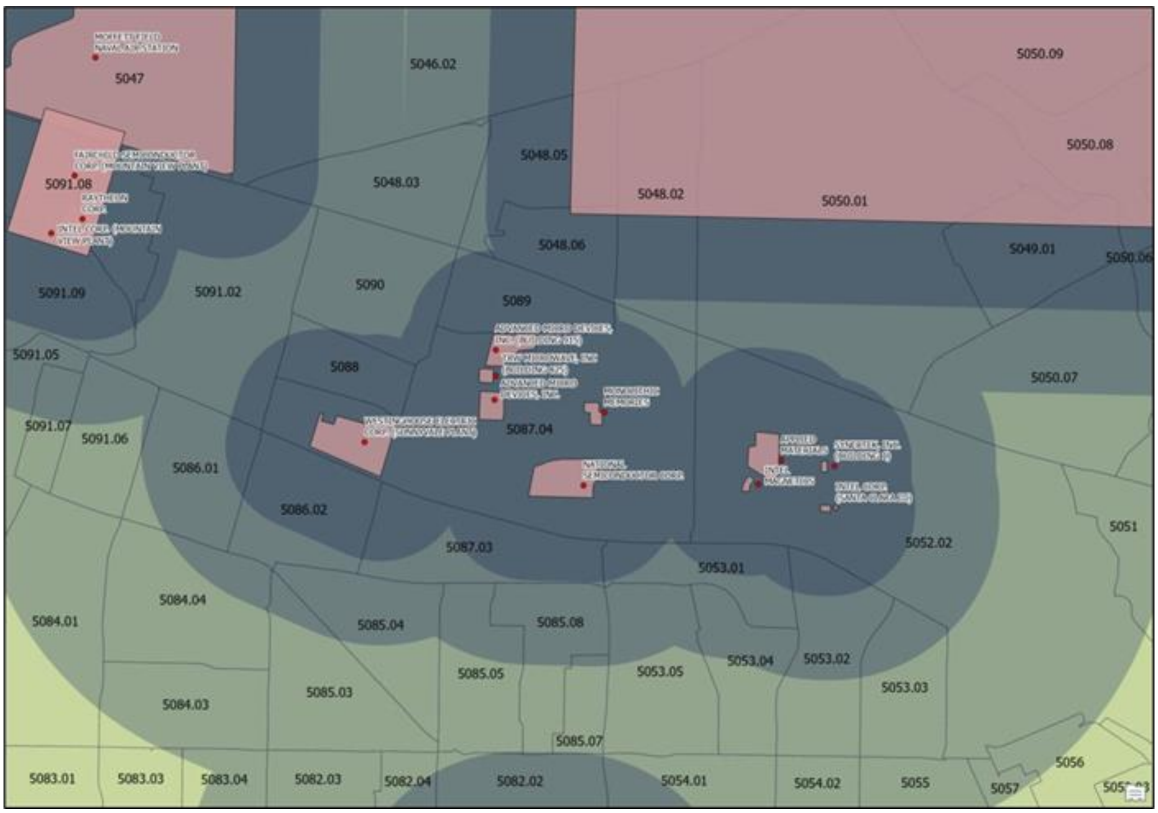

Figure 5 Closer view of NPL Site Polygons and Buffers

3.3.2. Tabulate Intersection Tool

The parameters used for the initial test of the tabulate intersection tool are visible in Figure 6 and are as follows: The half-mile buffer polygon layer set as the input zone feature while the 2010 demographic data is set as the input class feature. The class fields include tract_2010 (full census tract number), tract_name (shortened tract number), and Shape_Area (tract area in square meters). The Sum Fields included all race groups (for 2010 there are five groups) and total population count per tract. Square meters were selected as the Output Unit for the subsequent table and the tool was then run.

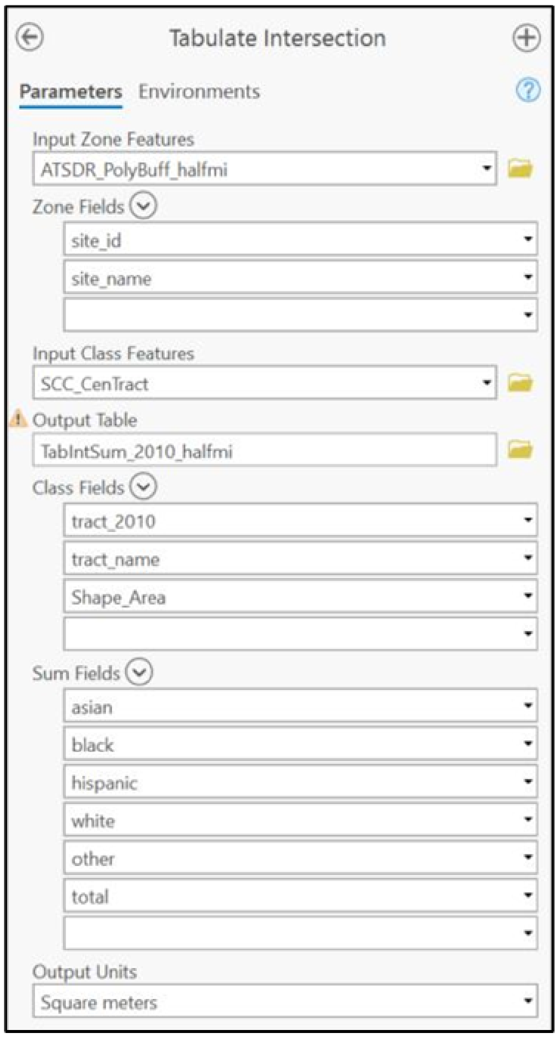

Figure 6 Tabulate Intersection Tool Parameter setup for 2010, half-mile polygon buffer zone

The test of the tabulate intersection tool ran successfully, providing counts for each census tract that intersected with or fell within every half-mile buffer zone boundary in a table. Part of that resulting table can be seen in Figure 7. Taking row 1 as an example, the table shows that its tract_name is 5087.04. The tract_area_intersection column shows what percent of the tract intersects or was as within the half-mile buffer zone for a given site. For row 1, tract 5087.04 it is .4235 or 42.35% which means that 42.35% of the tract fell within the boundaries of the half-mile buffer zone. The total column shows the amount of the population that was included based on the intersection percentage (tract_area_intersection) – approximately 2,213 people for tract 5087.04 (42.35% of tract 5087.04's normal 5,225.35-person population).

Lastly, the race fields display the proportional number of people from each race that were included in the total column. Taking Asian as an example, this group originally made up 42.47% (2,219.20 people) of tract 5087.04's original total population of 5,225,35 people. By listing Asian as one of the Sum fields (along with the other race group), the tabulate intersection tool considered that this group comprised 42.47% of the total population and should still make up 42.47% of the proportional population (2,213 people, 43.35% of the tract/population) considered as being within the half-mile zone buffer. This process was repeated for each year and buffer zone distance.

3.3.3. Summary Statistics

The summary statistics tool was then used to calculate the total number of individuals within a half-mile, 1-mile, and 2-mile of each site by race. As seen in Figure 7, the tabulate intersection tool returned one row for each census tract that fell within a site's half-mile buffer zone. While that is useful for tracking changes across individual tracts, knowing the total number of people within a particular site's buffer zone by race makes comparing changes across several years easier and more digestible. The tabulate intersection results table using the 2010, half mile buffer zone data was chosen as the Input Table; the asian, black, white, other, and total fields were added as Statistics Fields with Statistic Type set to Sum; and site_id and site_name were added as Case fields. Figure 8 shows part of the resulting table and now each site has only one row and count associated with for total population, the total number of people within each racial group, and the number of census tracts that fall within/intersect their respective half-mile zones. As with the tabulate intersection tool, this process was also completed for each year and each buffer distance.

	OBJECTID *	site_id	site_name	tract_2010	tract_name	tract_area	tract_area_intersect	tract_int_percentage	asian	black	hispanic	white	other	total	AREA	PERCENTAGE
1	65	CAD048634059	ADVANCED MICRO DEVICES, INC.	06085508704	5087.04	5997501.78062	2540011.891763	0.423512	940.195869	33.033909	506.943448	645.008247	88.513935	2213.695409	2540011.891763	87.739176
2	66	CAD048634059	ADVANCED MICRO DEVICES, INC.	06085508800	5088	695111.642521	63666.393562	0.091592	103.681701	7.235737	137.936963	85.363379	10.716218	344.933998	63666.393562	2.199217
3	67	CAD048634059	ADVANCED MICRO DEVICES, INC.	06085508900	5089	911941.293942	222797.700601	0.244311	427.300728	23.453899	537.729503	237.226419	62.543731	1288.25428	222797.700601	7.696061
4	68	CAD048634059	ADVANCED MICRO DEVICES, INC.	06085509000	5090	1537798.360676	68481.538983	0.044532	70.984321	5.87825	156.174414	84.210384	12.602612	329.84998	68481.538983	2.365546
5	118	CAT080034234	ADVANCED MICRO DEVICES, INC. (BUILDING 9	06085504802	5048.02	1829669.288315	9.591826	0.000005	0.01158	0.00044	0.006868	0.007266	0.001326	0.027481	9.591826	0.000295
6	119	CAT080034234	ADVANCED MICRO DEVICES, INC. (BUILDING 9	06085504805	5048.05	1450314.746851	6639.701163	0.004578	5.47542	0.517326	4.037893	13.130021	1.075856	24.236517	6639.701163	0.204181
7	120	CAT080034234	ADVANCED MICRO DEVICES, INC. (BUILDING 9	06085504806	5048.06	822728.885053	228334.052267	0.277533	316.387116	16.929486	300.012696	144.31693	35.524167	813.170396	228334.052267	7.021618
8	121	CAT080034234	ADVANCED MICRO DEVICES, INC. (BUILDING 9	06085508704	5087.04	5997501.78062	1863316.536487	0.310682	689.714295	24.233205	371.886491	473.168861	64.932562	1623.935414	1863316.536487	57.299803
9	122	CAT080034234	ADVANCED MICRO DEVICES, INC. (BUILDING 9	06085508800	5088	695111.642521	28153.424259	0.040502	45.848284	3.199659	60.996039	37.747881	4.738736	152.5306	28153.424259	0.86576
10	123	CAT080034234	ADVANCED MICRO DEVICES, INC. (BUILDING 9	06085508900	5089	911941.293942	903166.277521	0.990378	1732.170513	95.076255	2179.821212	961.6567	253.536679	5222.261359	903166.277521	27.773729
11	124	CAT080034234	ADVANCED MICRO DEVICES, INC. (BUILDING 9	06085509000	5090	1537798.360676	222252.943769	0.144527	230.375582	19.077526	506.855186	273.300016	40.90106	1070.50937	222252.943769	6.834614
12	60	CAD042728840	APPLIED MATERIALS	06085505001	5050.01	8933204.409817	139899.57761	0.015661	84.23851	4.212709	23.459618	34.155826	6.483499	152.550163	139899.57761	4.354308
13	61	CAD042728840	APPLIED MATERIALS	06085505202	5052.02	9206489.211662	2619350.974791	0.284511	420.223312	65.437618	693.923262	417.093687	72.550403	1669.228282	2619350.974791	81.526057
14	62	CAD042728840	APPLIED MATERIALS	06085505301	5053.01	923566.424558	110067.823754	0.119177	175.07093	11.917694	195.331011	116.435874	28.48329	527.238799	110067.823754	3.425809
15	63	CAD042728840	APPLIED MATERIALS	06085505302	5053.02	1438774.748382	23464.571776	0.016309	17.319859	1.467785	16.194557	27.61066	2.886643	65.479503	23464.571776	0.730324
16	64	CAD042728840	APPLIED MATERIALS	06085508704	5087.04	5997501.78062	320117.390581	0.053375	118.492771	4.16326	63.890021	81.290311	11.155401	278.991764	320117.390581	9.963502
17	40	CAD009212838	CTS PRINTEX, INC.	06085504601	5046.01	28078874.226613	1112661.512684	0.039626	4.279639	1.06991	8.281894	16.444909	2.298325	32.374676	1112661.512684	42.561827

4 of 124 selected Filters: 100%

Figure 7 Resulting table for Tabulate Intersection tool for 2010 census data and half-mile polygon buffers

	OBJECTID *	site_id	site_name	FREQUENCY	SUM_asian	SUM_black	SUM_hispanic	SUM_white	SUM_other	SUM_total
1	13	CAD048634059	ADVANCED MICRO DEVICES, INC.	4	1542.162619	69.601795	1338.784328	1051.808429	174.376497	4176.733668
2	23	CAT080034234	ADVANCED MICRO DEVICES, INC. (BUILDING 9	7	3019.982792	159.033898	3423.616385	1903.327675	400.710387	8906.671137
3	12	CAD042728840	APPLIED MATERIALS	5	815.345382	87.199065	992.79847	676.586358	121.559235	2693.48851
4	8	CAD009212838	CTS PRINTEX, INC.	5	912.986536	90.058317	947.363537	1616.09115	169.219127	3735.718666
5	17	CAD095989778	FAIRCHILD SEMICONDUCTOR CORP. (MOUNTAIN	6	2684.404217	282.155091	1642.244612	3403.466944	416.705283	8428.976147
6	18	CAD097012298	FAIRCHILD SEMICONDUCTOR CORP. (SOUTH SAN	5	1090.903746	233.88891	1776.826562	2568.010874	275.755914	5945.386006
7	19	CAD980884209	HEWLETT-PACKARD (620-640 PAGE MILL ROAD)	7	890.070423	92.850131	282.714272	2056.04533	173.693496	3495.373651
8	15	CAD061620217	INTEL CORP. (MOUNTAIN VIEW PLANT)	6	2684.404217	282.155091	1642.244612	3403.466944	416.705283	8428.976147
9	22	CAT000612184	INTEL CORP. (SANTA CLARA III)	3	676.384186	76.110303	891.912893	704.745784	113.800332	2462.953497
10	16	CAD092212497	INTEL MAGNETICS	4	831.057187	77.793868	1007.561086	661.246176	129.787337	2707.445656
11	10	CAD041472341	INTERSIL INC./SIEMENS COMPONENTS	7	3585.989113	112.931931	869.851672	3072.915538	325.524178	7967.212432
12	3	CAD009103318	JASCO CHEMICAL CORP.	6	2723.507996	289.806957	4771.568561	4683.795175	532.90088	13001.579569
13	9	CAD029295706	LORENTZ BARREL & DRUM CO.	5	1539.638242	171.834813	2487.559653	659.201544	124.889844	4983.124096
14	1	CA2170090078	MOFFETT NAVAL AIR STATION	7	2179.39969	304.737941	1515.763754	2534.764903	346.919557	6881.585845
15	14	CAD049236201	MONOLITHIC MEMORIES	2	1085.314199	40.902066	686.027075	726.217965	109.497904	2647.959209
16	11	CAD041472986	NATIONAL SEMICONDUCTOR CORP.	3	3160.237205	160.716989	1414.911056	1849.245402	299.29944	6884.410091
17	7	CAD009205097	RAYTHEON CORP.	4	1609.339734	168.383842	1063.979793	2065.193858	254.317171	5161.214398

1 of 23 selected

Figure 8 Resulting table for Summary Statistics calculated for 2010 census data and half-mile polygon buffer

3.4. Assessing Disparate Distribution and Demographic Change

In order to determine whether there is a disparity in the distribution of the twenty-three SCC NPL sites, the difference in racial composition of the population within the buffer areas and outside the buffer areas/within the study area as a whole will be compared. Two key expectations/assertions for this study are that race-related environmental inequality exists and one manifestation of this inequality is the disproportional concentration of certain demographic groups (Non-White) within the superfund site zone boundaries compared to other groups (White). Notably, a race (non-white to white) ratio for individuals inside the boundary does not take into account the racial composition for the greater area (SCC). For example, in 2000 there were 62,509 White individuals within a half-mile of a NPL site compared to just 29,983 Non-white individuals. This ratio ends up being 2.08 or 208 White people for every 100 Non-White (alternatively 47 Non-White for every 100 White individuals). Thus, to better assess and demonstrate the existence of this expectation of environmental inequality, a location quotient comparing the ratios for a demographic group inside and outside of a site-zone boundary to the ratio of the population within and outside those boundaries as a whole is utilized.

$$Location\ Quotient\ = \frac{(X/\Sigma X)}{(N/\Sigma N)} = \frac{[Demographic\ group]\ within\ boundary\ Ratio}{[Demographic\ group]\ within\ county\ Ratio}$$

X = [Demographic group] population in site-zone boundary
ΣX = Total population in site-zone boundary
N = [Demographic group] population in county
ΣN = Total population in county

Ideally, across all years studied, there would be little to no difference between the in-zone and outside-of-zone population ratios meaning that no demographic group is disproportionally located near superfund sites. For example, if the county's overall population is observed to be 60% White, 40% Non-White and the population within the site-zone boundary is also 60%

White, 40% Non-White, then the resulting LQ values for each demographic group would equal 1 (LQ = 1). However, it is expected that some demographic groups will be disproportionally concentrated within site zones compared to other groups. In these cases, An LQ > 1 indicates a higher spatial concentration or overrepresentation for the selected demographic group within a site-zone compared to the expected population proportions for the greater region. Conversely, an LQ < 1 indicates that the observed counts for a particular demographic group is lower than expected within a site-zone when compared to the greater region's expected population proportions. For this study the "greater region" is Santa Clara County and the expected population proportions have been collected for each decennial year from 1960 through 2010.

3.4.1. Assessing Demographic Change

The secondary aim of this project entails assessing how the demographic makeup around sites changed over time. Key environmental justice (EJ) studies referenced in Chapter 2 involved researchers attempting to determine whether the disparate siting of polluted locations occurred due to the existing and historical population makeup of an area, or if post-siting demographic changes occurred in surrounding area after the site was established. Ideally, this project's analysis would be similar; ascertaining whether the makeup of the community influenced the establishment and persistence of SCC's superfund sites or if the establishment of a site/official listing of a site on the NPL affected the subsequent demographic composition of the surrounding community. However, given the complex nature and variability of socio-economic factors across time and place, the findings of this project's analysis are unlikely to provide a concrete answer one of the longest standing questions in the EJ field. In spite of this, the results gleaned from this portion of the analysis can still provide additional context regarding how NPL sites seem to have affected SCC historically and today.

The county's demographic composition changes will be assessed using percent-change between years for the two FCGs (White and Non-White) across each buffer zone distance for each site. If post-siting demographic change is not at all a factor, then the percent change among the populations found within each buffer distance and site should mirror the percent change found across the greater, county study area.

Chapter 4 Results

Longitudinally assessing the spatial distribution of Superfund/National Priority Listed sites in SCC was a multi-step process. While the findings of this particular project are unlikely to answer one of the longest standing questions regarding environmental disparities and race, the results can still assist in providing a more complete picture of the superfund site situation in Santa Clara County historically and today.

4.1. Condensed and Partially Condensed Race Categories

As previously mentioned in Chapter 3, two race grouping methods – "Condensed" and "Partially Condensed" were utilized to address the decade-to-decade inconsistencies present in US Census data aggregated by race. The Condensed method only has two categories: White and Non-White, while Partially Condensed includes: White, Black, American Indian/Native American, Asian, and Other. For the "Condensed" grouping the "White" category includes individuals who self-identified as "White, alone" while "Non-White" includes those self-identifying as any group other than "White, alone." Then, for the partially Condensed group, Asian combines counts for Asian and Native Hawaiian and Other Pacific Islander while the "Other" subgroup combines counts for Other and Two or More Races/Multiracial.

Figure 9 utilizes the five categories from the Partially Condensed grouping method and shows which race category was predominant in each census tract for a given decennial census year. The map also visualizes the largest race category's relative predominance with variable transparency – the lighter the color, the less a predominant race category comprises of a tract's overall population. From 1960 to 2010, White is the predominant race category for most census tracts but starting in 1980 the relative predominance for White markedly begins decreasing.

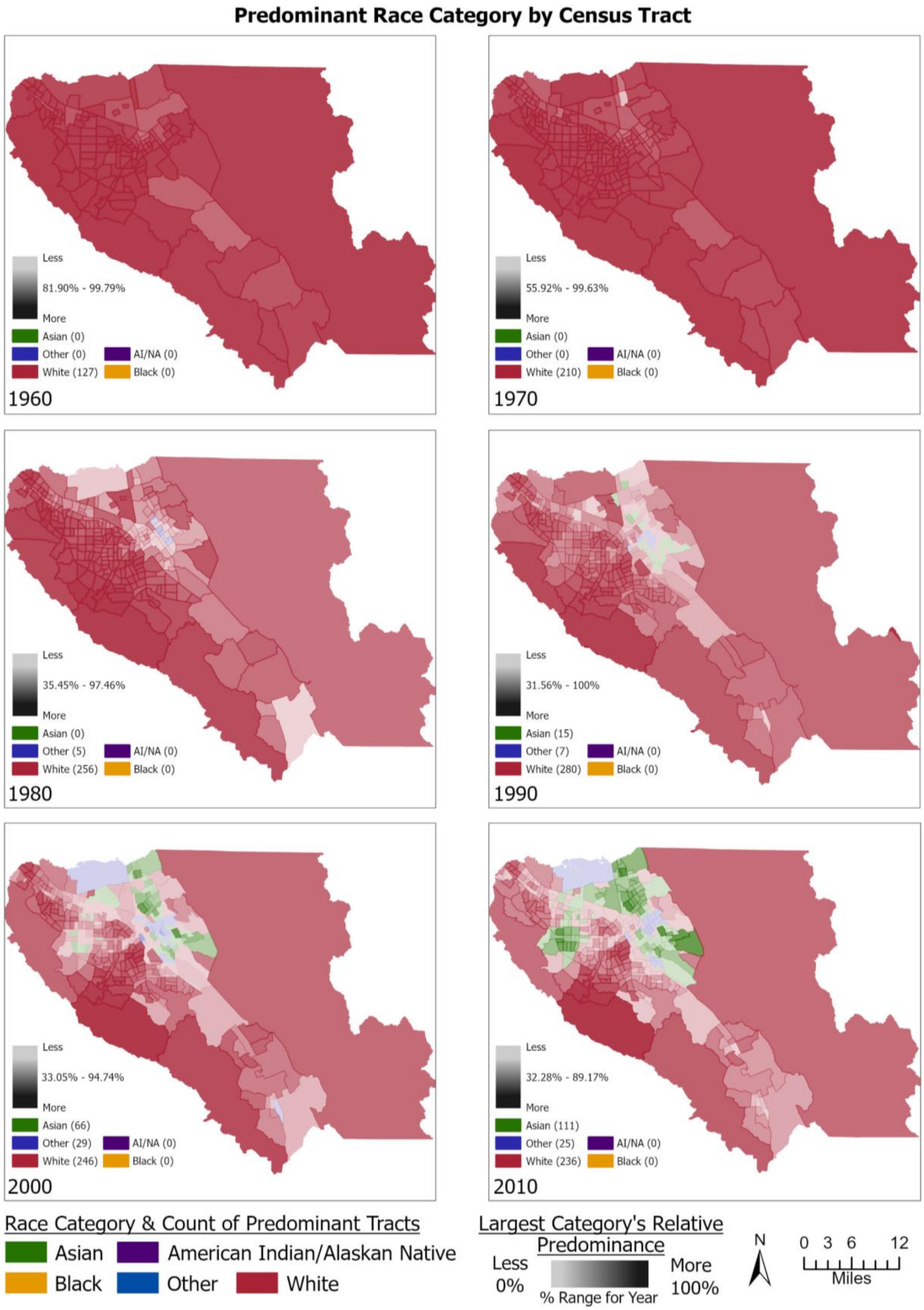

Figure 9 Partially Condensed Race Category Predominance 1960 - 2010

In 1990 7.9% of census tracts have Other or Asian as the predominant category which increased to 27.9% in 2000 and 36.6% in 2010. Even in the census tracts where White remained the largest group proportionally the predominance relative to the other categories markedly decreased. Interestingly, the areas where relative predominance first began shifting in the county, specifically the north-central portion of the county, is where the City of San Jose is located.

The decade-to-decade shifts seen in Figure 9 regarding predominant race categories spatially aligns with changes seen in the county's population density over the same 1960-2010 period (Figure 10). The entire county saw an increase in population and subsequently population density across those years, but Figure 10 shows that the census tracts with the highest population densities were also spatially located in the same areas where relative predominance for White deceased starting in 1980. Since changing boundaries, numbers, and names complicates the direct one-to-one comparison of a specific tracts across decennial censuses, the additional spatial and temporal context Figures 9 and 10 provide about the county's demographic change over a fifty-year period is valuable.

Figure 11 uses data from the Condensed grouping method to visualize the Non-White category from 1960 – 2010 in conjunction with NPL site points, boundaries, and a 2-mile buffer. The NPL sites are mainly clustered around the north-west portion of the county, specifically in the cities of Santa Clara, Sunnyvale, and Mountain View. In 1960 and 1970, the majority of census tracts in the county and within 2 miles of an NPL site boundary was comprised of White individuals and Non-White made up less than 30.7% of a tract's population. In 1980 this begins to shift when 23.5% or 33 of the 140 tracts partially within the 2-mile-buffer have a Non-White proportion of at least 30.8%. The number of sites has also increased in the north-west portion of the county, filling-in the aforementioned cluster. In 2000, 40.65% of tracts (69 of 170) partially within 2 miles have Non-White proportions of at least 50.7%, and by 2010 this amount has grown to 58.4% (104 of 178) of those tracts at least partially within 2-miles.

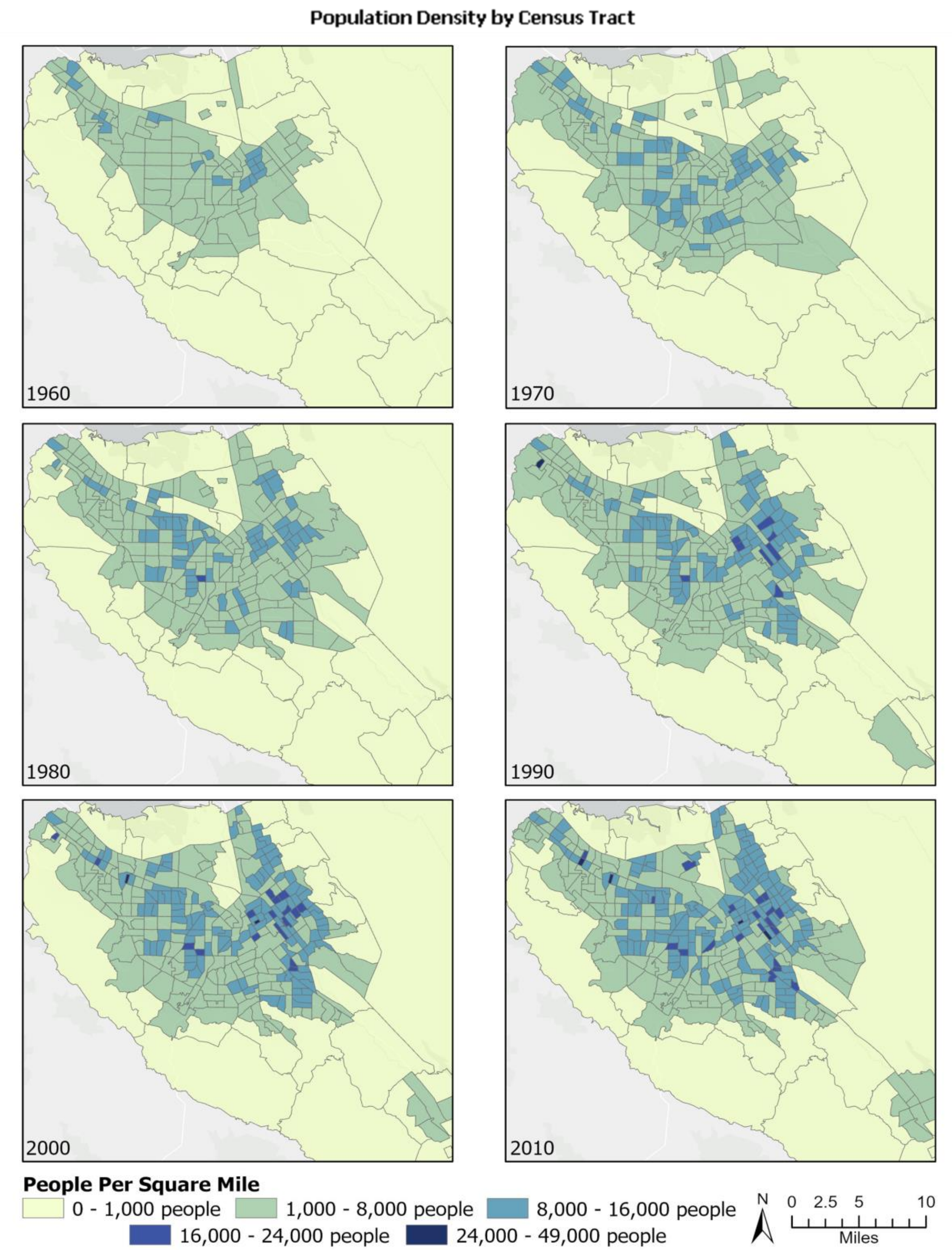

Figure 10 Population Density by Census Tract 1960 - 2010

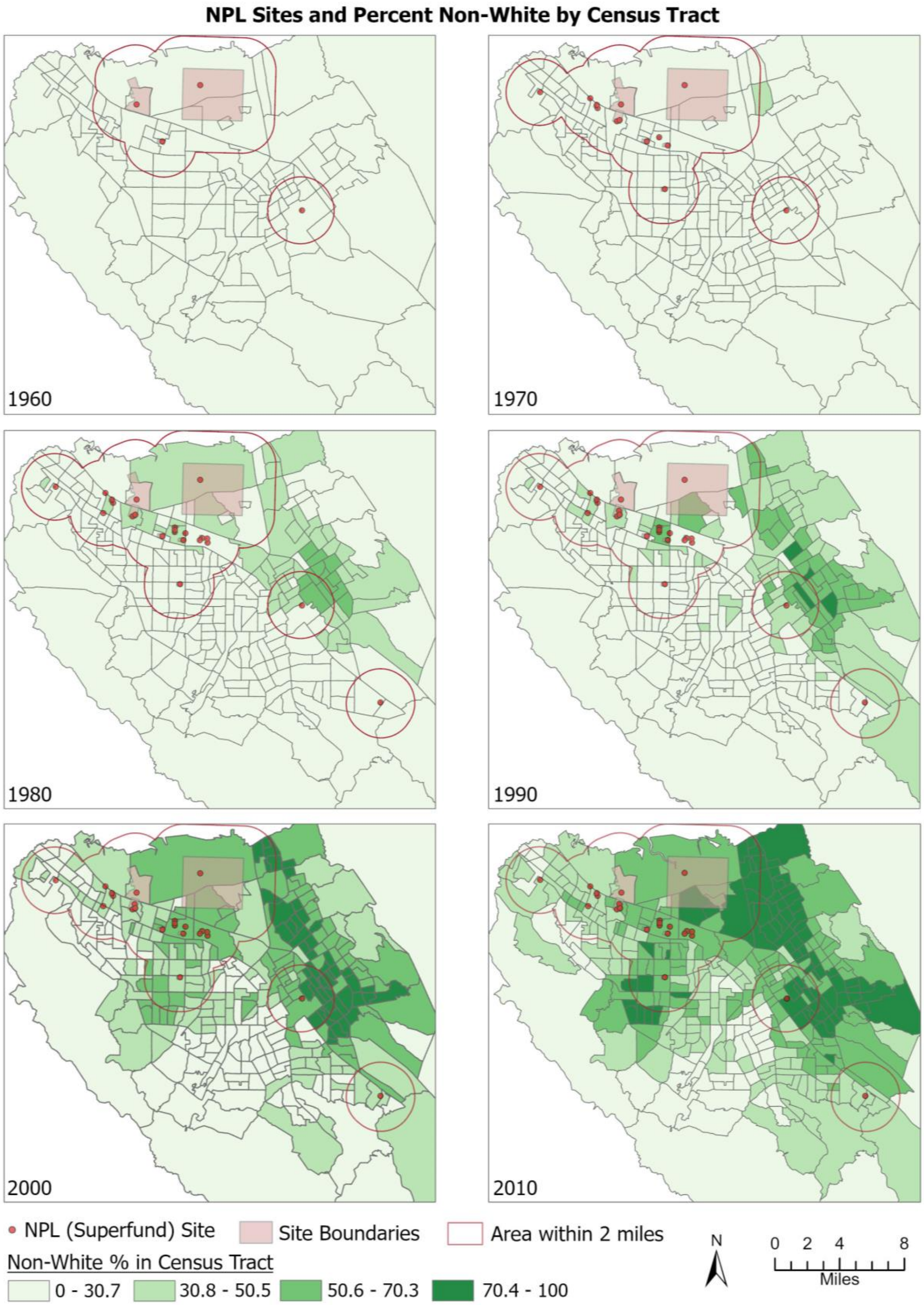

Figure 11 NPL Site Boundaries and % Non-White

4.2. Disparate Site Distribution Results

Area-apportionment, an area-weighting method, along with summary statistics and location quotient were used to analyze the distribution of Superfund/NPL sites within Santa Clara County. The demographic makeup of areas within .5, 1, or 2-miles of a site boundary were determined using the methods outlined in Chapter 3. The resulting in-zone demographic ratios were compared against the greater study area's population proportions as a whole in order to provide insight on the phenomena of disparate, hazardous site distribution within the county. The county-wide, demographic proportions (presented in Table 3) and area-weighted results (Tables 4-6) were critical components of the project analysis.

Santa Clara County, County-Wide Demographic Breakdown							
	1950 (n = 95,280)	**1960** (n = 642,315)	**1970** (n = 1,064,714)	**1980** (n = 1,295,071)	**1990** (n = 1,497,577)	**2000** (n = 1,682,585)	**2010** (n = 1,781,642)
% White	97.85%	96.78%	94.29%	78.59%	68.92%	53.83%	46.96%
% Non-White	2.15%	3.22%	5.71%	21.41%	31.08%	46.17%	53.04%
% American Indian/ Native Alaskan	-	-	0.38%	0.66%	0.62%	0.67%	0.73%
% Asian	-	-	3.06%	7.72%	17.46%	25.56%	32.02%
% Black	0.62%	0.65%	1.70%	3.38%	3.75%	2.80%	2.61%
% Other	1.53%	2.57%	0.57%	9.66%	9.24%	16.79%	17.29%

n = Total County Population

Table 3 SCC Demographic Proportions from 1950-2010

4.2.1. Demographic Breakdown

Three "in-site-zones" were determined for each of the NPL sites for every decennial census year from 1960 through 2010. These zones included individuals living within a half-mile, 1-mile, and 2-miles from an NPL site boundary. In addition to providing a more realistic area of effect regarding the sites' pollutants, the area-apportionment method was used in tandem with the Tabulate Intersection tool to circumvent issues arising from census tract boundaries changing over time. Tables 4, 5, and 6 display the percentage of the county's population residing within each "boundary zone" distance along with the respective zones' demographic breakdown across every year of interest for both Condensed and Non-Condensed sub-groupings. Since historical population counts for the study area at the census tract level were not readily available for years between the decennial survey years, the operation start year for an NPL site was not considered when determining the general "in-zone" and "outside-of-zone" counts.

For example, in 2010, Santa Clara County had over 1.7 million (1,7891,642) inhabitants with 46.96% self-identifying as "White, alone" and the other 53.04% self-identifying as a group other than "White, alone" – hereafter referred to as Non-White. Following the Partially Condensed subgroupings, the Non-White group's demographic breakdown was .73% American Indian/Alaskan Native, 32.03% Asian (Condensed), 2.61% Black, and 17.29% Other (Condensed). Around 7.17% of the county's population or approximately 127,671people were living within a half-mile of a superfund site. Of this half-mile group, 43.4% self-identified as White, alone while the remaining 56.6% were Non-White. Of the 279,460 people living within

Demographic Breakdown for areas within a half-mile of sites by Percentage						
	1960	**1970**	**1980**	**1990**	**2000**	**2010**
Of total County Population	8.15%	6.56%	6.25%	6.18%	6.45%	7.17%
White	95.80%	93.15%	73.59%	67.58%	51.81%	42.54%
Non-White	4.20%	6.85%	26.41%	32.42%	48.19%	57.46%
American Indian/ Native Alaskan	0.00%	0.43%	0.82%	0.70%	0.65%	0.62%
Asian	0.00%	4.25%	11.84%	18.95%	28.84%	37.71%
Black	0.82%	1.61%	3.97%	4.41%	3.13%	2.93%
Other	3.38%	0.56%	9.78%	8.36%	15.57%	16.20%

Table 4 SCC Demographics for areas within a half-mile of NPL Sites

1-mile, 42.54% were White while 57.46 were Non-white. Then of the 636,435 people (35.72% of county population) within 2-miles, 44.11% were White and 55.89% were Non-White.

Demographic Breakdown for areas within 1-mile of sites by Percentage						
	1960	**1970**	**1980**	**1990**	**2000**	**2010**
Of total County Population	18.77%	15.97%	15.14%	15.06%	15.16%	15.69%
White	96.34%	93.56%	76.06%	68.64%	52.50%	43.74%
Non-White	3.66%	6.44%	23.94%	31.36%	47.50%	56.26%
American Indian/ Native Alaskan	0.00%	0.38%	0.72%	0.64%	0.63%	0.63%
Asian	0.00%	4.00%	10.63%	18.35%	28.35%	36.78%
Black	0.62%	1.51%	3.64%	4.12%	2.91%	2.72%
Other	3.04%	0.55%	8.95%	8.25%	15.61%	16.13%

Table 5 SCC Demographics for areas within 1-mile of NPL Sites

Demographic Breakdown for areas within 2-miles of sites by Percentage						
	1960	**1970**	**1980**	**1990**	**2000**	**2010**
Of total County Population	44.88%	39.10%	35.55%	35.16%	34.90%	35.72%
White	96.73%	93.43%	77.22%	68.28%	51.98%	44.11%
Non-White	3.27%	6.57%	22.78%	31.72%	48.02%	55.89%
American Indian/ Native Alaskan	0.00%	.40%	0.67%	0.60%	0.61%	0.63%
Asian	0.00%	3.67%	9.27%	18.15%	28.37%	36.57%
Black	0.68%	1.89%	3.56%	3.85%	2.75%	2.68%
Other	2.59%	0.61%	9.28%	9.12%	16.29%	16.01%

Table 6 SCC Demographics for areas within 2-miles of NPL Sites

4.2.2. Location Quotient

The calculated location quotients (LQ) for the White and Non-White Condensed groups across the three site-zone distances have been visualized in Figures 12, 13, and 14 (full tables can be found in Appendix A). The LQ results show that across all years and "in-site-zone" distances there *is* a spatial disparity present for one of the Condensed Demographic groups. The Non-White demographic group is shown to have an LQ value of greater than 1 for every study year which indicates that there is a higher spatial concentration or over-representation of individuals of this particular group within the areas 2 miles and closer to NPL site boundaries. The White, Condensed Group consistently had LQ values less than one (or nearly equal) to one. LQ values less than 1 indicate a lower spatial concentration or under-representation of the demographic group within the three site-zone-distances and an LQ value of 1 meaning that the spatial concentration is in-line with the greater, county population breakdown (e.g., 40% of the county is White and 40% of individuals within the given site-zone-distance is also White).

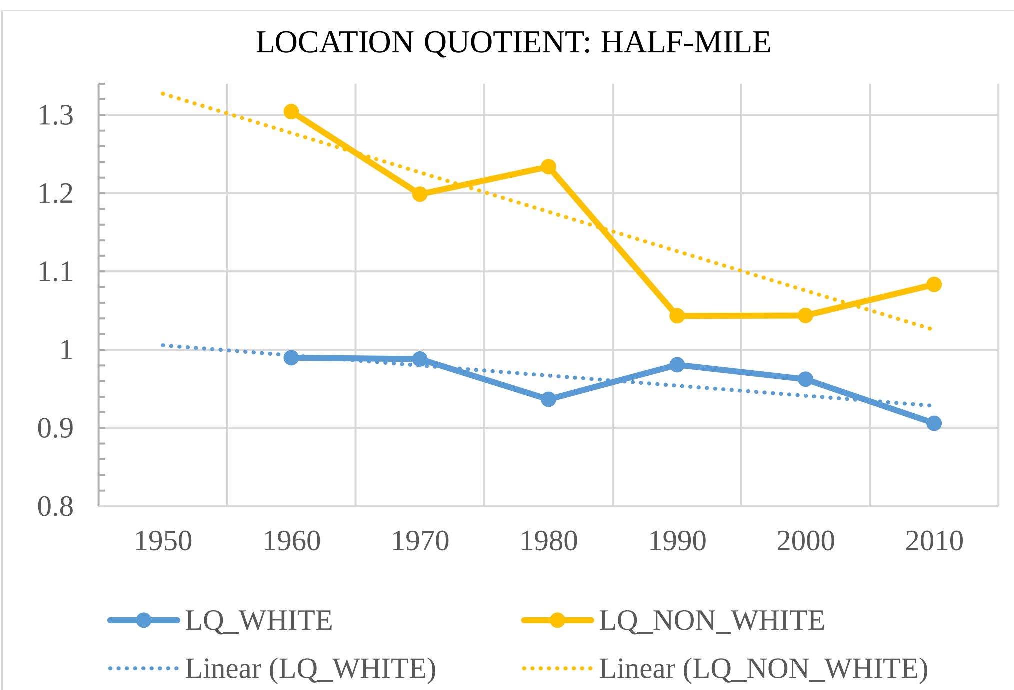

Figure 12 Location Quotient for .5-mile, dissolved buffer zone 1960 - 2010

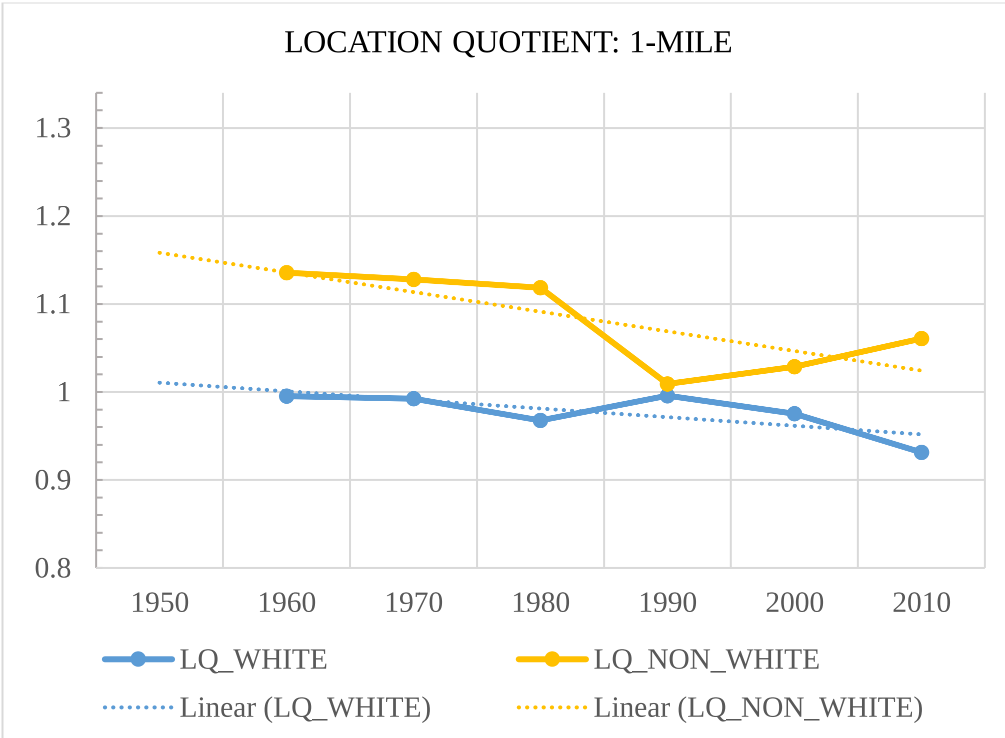

Figure 13 Location Quotient for 1-mile, dissolved buffer zone, 1960 – 2010

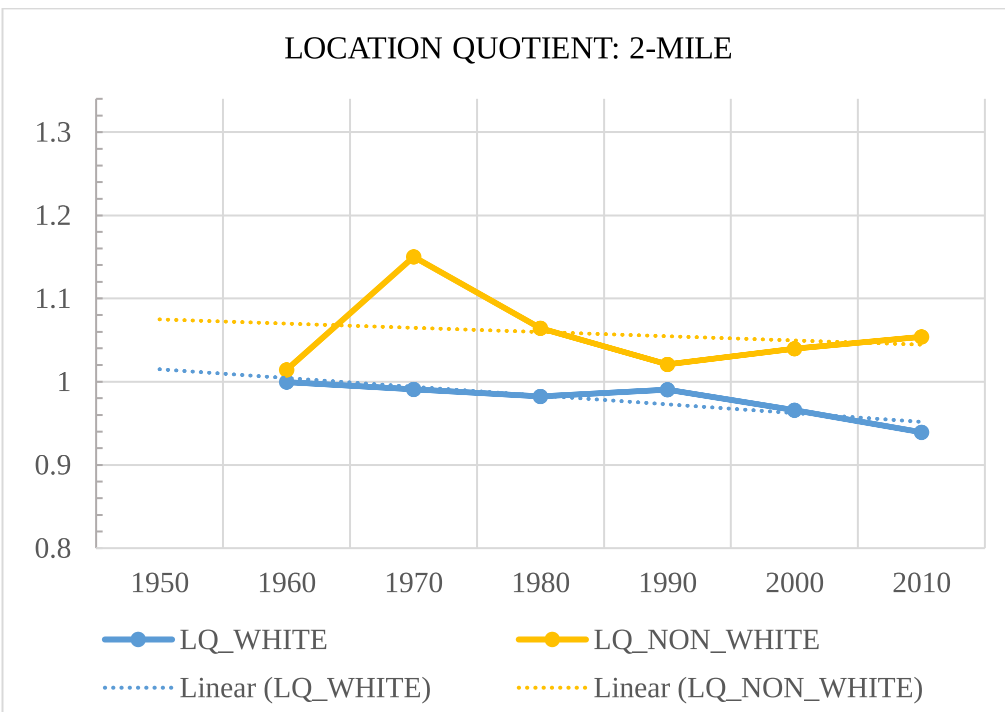

Figure 14 Location Quotient for 2-mile, dissolved buffer zone 1960 - 2010

Chapter 5 Discussion and Conclusions

This study assessed the spatial distribution of National Priority Listed (Superfund) sites in Santa Clara County (SCC) and examined how the demographic makeup of the areas surrounding those sites changed from 1960 through 2010. This concluding chapter provides a deeper discussion of the results, limitations of the study, overall implications, as well as suggestions for further research.

5.1. Discussion

The results of this project's analyses are in-line with the generally accepted trend that the burden of environmental hazards has historically, and currently still is, disproportionately located within non-white, low-income communities. While this pattern is especially apparent in areas where racial and socio-economic stratification is prevalent, it does still occur in areas that many would consider to be racially/ethnically diverse and have generally progressive environmental policies – such as Santa Clara County.

5.1.1. Assessing Disparate Siting and Post-Siting Demographic Change

Despite Whites making up the majority of SCC's population from 1960-2010, individuals within the non-white groups were disproportionately represented/found within the communities immediately surrounding NPL listed sites. In terms of percent change, SCC experienced continued population growth across study years (US Census Bureau 2021a). However, when looking at condensed race groupings (Table 7), Non-White grew from across all study years with a positive percent change while White only experienced growth between 1950-1990 then saw a decline from 1990 onward.

When looking at the percent change for the areas surrounding individual NPL sites, (Appendix B) it is apparent that the areas closest to these sites does not align with the county-wide percentage changes for the coinciding decades. With the exception of a handful of sites, the presence of Non-White individuals residing within 2-miles increased across all study years while the presence of White individuals typically saw a decline/negative percent change across the majority of years. Interestingly, for 10 out of 23 sites, there seemed to be an increase in the number of white individuals within 2-miles of sites between 1990 and 2000 which does not follow the county-wide trend for percent change during that time period. Regardless of if a specific site followed the same general growth/decline county trend for the given time period, the *magnitude* of the percent changes between site and county were wildly different.

County-Wide Percent Change						
	1950-1960	**1960-1970**	**1970-1980**	**1980-1990**	**1990-2000**	**2000-2010**
White (%)	5.668	0.615	0.014	0.014	-0.123	-0.076
Non-White (%)	9.098	1.939	3.558	0.679	0.669	0.216
American Indian/ Native Alaskan (%)	-	-	1.101	0.090	0.225	0.142
Asian (%)	-	-	2.063	1.616	0.645	0.327
Black (%)	6.085	3.321	1.417	0.286	-0.161	-0.016
Other (%)	10.319	-0.633	19.651	0.107	1.041	0.090

Table 7 County-Wide Percent Change 1950-2010

5.2. Limitations

Historical census data and shapefiles for the study area were limited with census tracts being the smallest unit available and readily accessible for the entire study period. The use of census block groups or blocks would have likely provided a clearer view of the communities surrounding Superfund sites. This data availability limitation extended to zoning data prior to

2010, where the use of zoning layers could have increased the accuracy of the county's actual residential land area during the area-weighting and tabulate intersection process.

Similarly, more detailed data regarding census respondent ethnicity was not readily accessible across all study years and thus not included. Even barring the intrinsic issues and complexities surrounding/related to race and ethnicity with their continually changing definitions, the inclusion of this data would have provided a clearer understanding of the communities surrounding SCC's NPL sites prior to and after their construction.

Furthermore, while the project's results do align with the generally accepted patterns between disparate environmental burdens and race, there are a myriad of other factors affecting when, where, and why people choose to move into and away from an area. This is particularly important in the case of SCC where a boom in technology/software related jobs occurred alongside and contributed to some of the highest costs of living in the country and issues related to housing availability/affordability which have only continued to spiral in the past two decades and cannot be addressed quickly enough. Thus, the inclusion of additional sociodemographic variables such as socioeconomic status, education level, home ownership, and median housing/rent costs in this project's analysis, across the study year, would have provided valuable, additional context and which in turn could have increased the robustness of this project's findings.

5.3. Future Research and Implications

While the findings of this particular project are unlikely to answer one of the longest standing questions regarding environmental disparities and race, the results can still assist in providing a more complete picture of the superfund site situation in Santa Clara County historically and today.

This project’s findings can serve as a starting point for further, target analysis of the NPL sites and demographic changes that have occurred in Santa Clara. A closer analysis centered on individual NPL site trends across time would be a logical next step since it can directly build upon the findings from this project. Then, the inclusion of additional sociodemographic variables such as socioeconomic status, education level, home ownership, and median housing/rent costs would provide additional context and increase the robustness of the findings. The use of historical data such as redlining maps, which came into use around the 1930s, could also provide further social context or reasoning behind why white and non-white individuals were located where they were prior to the majority of SCC’s sites being built. Additionally, utilizing zoning layers could increase the accuracy of the county’s residential land area during the area-weighting and tabulate intersection process. Thus, if the previously mentioned limitations were addressed and additional datasets and analyses were incorporated, an even better understanding of environmental disparities and their effect upon SCC and its residents across the years could be gleaned.

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Appendix A Location Quotient Results

Location Quotient for Non-White 1960-2010

Location Relative to Site Boundary	**Non-White Count**	**Non-White Percentage**	**Region Population**	**Region Population Percentage**	**Location Quotient** (%Non-White/ %Region)
2010					
Within Half-Mile	73354	0.077621145	127671	0.071659177	1.083198939
Outside Half-Mile	871672	0.922378855	1653971	0.928340823	0.993577825
Within 1-Mile	157231	0.166377433	279460	0.156855305	1.060706443
Outside 1-Mile	787795	0.833622567	1502182	0.843144695	0.988706413
Within 2-Mile	355734	0.376427738	636435	0.357218229	1.053775278
Outside 2-Mile	589292	0.623572262	1145207	0.642781771	0.970115037
2000					
Within Half-Mile	52318	0.067339833	108562	0.06452096	1.04368926
Outside Half-Mile	724607	0.932660167	1574023	0.93547904	0.996986706
Within 1-Mile	133906	0.147854603	255057	0.151586398	0.975381729
Outside 1-Mile	771754	0.852145397	1427528	0.848413602	1.004398556
Within 2-Mile	281939	0.362890884	587170	0.348968997	1.039894337
Outside 2-Mile	494986	0.637109116	1095415	0.651031003	0.978615632
1990					
Within Half-Mile	29983	0.064425951	92492	0.061761098	1.043147756
Outside Half-Mile	435404	0.935574049	1405085	0.938238902	0.997159729
Within 1-Mile	70752	0.152028312	225597	0.150641336	1.009207141
Outside 1-Mile	394635	0.847971688	1271980	0.849358664	0.998367031
Within 2-Mile	167020	0.358884112	526508	0.351573241	1.020794729
Outside 2-Mile	298367	0.641115888	971069	0.648426759	0.988725218
1980					
Within Half-Mile	21366	0.077073473	80908	0.062474	1.23369284

Outside Half-Mile	255850	0.922926527	1214163	0.937526	0.984427445
Within 1-Mile	46941	0.169330053	196047	0.151379	1.118580959
Outside 1-Mile	230275	0.830669947	1099024	0.848621	0.978847194
Within 2-Mile	104906	0.378426931	460427	0.355523	1.064424422
Outside 2-Mile	172310	0.621573069	834644	0.644477	0.964460604
1970					
Within Half-Mile	4782	0.078630624	69842	0.065597	1.198693132
Outside Half-Mile	56034	0.921369376	994872	0.934403	0.986051346
Within 1-Mile	10952	0.180084188	169992	0.15966	1.127924588
Outside 1-Mile	49864	0.819915812	894722	0.84034	0.975695069
Within 2-Mile	27347	0.449667851	416284	0.390982	1.150098625
Outside 2-Mile	33469	0.550332149	648430	0.609018	0.903638549
1960					
Within Half-Mile	2199	0.106283229	52339	0.081485	1.304329697
Outside Half-Mile	18491	0.893716771	589976	0.918515	0.973001763
Within 1-Mile	4410	0.213146448	120562	0.187699	1.135574729
Outside 1-Mile	16280	0.786853552	521753	0.812301	0.968672609
Within 2-Mile	9419	0.455244079	288274	0.448805	1.014347811
Outside 2-Mile	11271	0.544755921	354041	0.551195	0.988317453

Location Quotient Results Table for Non-White.

Location Quotient for White 1960-2010

Location Relative to Site Boundary	**White**	**White Percentage**	**Region Population**	**Region Population Percentage**	**Location Quotient** (%White/ %Region)
2010					
Within Half-Mile	54317	0.064924649	127671	0.071659177	0.906020014
Outside Half-Mile	782299	0.935075351	1653971	0.928340823	1.007254371

Within 1-Mile	122229	0.146099286	279460	0.156855305	0.931427122
Outside 1-Mile	714387	0.853900714	1502182	0.843144695	1.012757027
Within 2-Mile	280701	0.335519522	636435	0.357218229	0.939256438
Outside 2-Mile	555915	0.664480478	1145207	0.642781771	1.033757503
2000					
Within Half-Mile	56244	0.062102776	108562	0.06452096	0.962520948
Outside Half-Mile	849416	0.937897224	1574023	0.93547904	1.002584969
Within 1-Mile	133906	0.147854603	255057	0.151586398	0.975381729
Outside 1-Mile	771754	0.852145397	1427528	0.848413602	1.004398556
Within 2-Mile	305231	0.337026036	587170	0.348968997	0.965776442
Outside 2-Mile	600429	0.662973964	1095415	0.651031003	1.018344688
1990					
Within Half-Mile	62509	0.060559587	92492	0.061761098	0.980545825
Outside Half-Mile	969681	0.939440413	1405085	0.938238902	1.001280603
Within 1-Mile	154845	0.150015985	225597	0.150641336	0.995848745
Outside 1-Mile	877345	0.849984015	1271980	0.849358664	1.000736262
Within 2-Mile	359488	0.348276965	526508	0.351573241	0.99062421
Outside 2-Mile	672702	0.651723035	971069	0.648426759	1.005083499
1980					
Within Half-Mile	59542	0.058497527	80908	0.062474	0.936353023
Outside Half-Mile	958313	0.941502473	1214163	0.937526	1.004241234
Within 1-Mile	149106	0.146490414	196047	0.151379	0.967704104
Outside 1-Mile	868749	0.853509586	1099024	0.848621	1.005761033
Within 2-Mile	355521	0.349284525	460427	0.355523	0.982453807
Outside 2-Mile	662334	0.650715475	834644	0.644477	1.009679266
1970					
Within Half-Mile	65060	0.064807381	69842	0.065597	0.987963198

Outside Half-Mile	938838	0.935192619	994872	0.934403	1.000845008
Within 1-Mile	159040	0.158422469	169992	0.15966	0.992250346
Outside 1-Mile	844858	0.841577531	894722	0.84034	1.001472389
Within 2-Mile	388937	0.38742681	416284	0.390982	0.990907046
Outside 2-Mile	614961	0.61257319	648430	0.609018	1.005837563
1960					
Within Half-Mile	50140	0.080659562	52339	0.081485	0.989870772
Outside Half-Mile	571485	0.919340438	589976	0.918515	1.000898602
Within 1-Mile	116152	0.186852202	120562	0.187699	0.995487567
Outside 1-Mile	505473	0.813147798	521753	0.812301	1.001042693
Within 2-Mile	278855	0.448590388	288274	0.448805	0.999522451
Outside 2-Mile	342770	0.551409612	354041	0.551195	1.000388839

Location Quotient Results for White.

Appendix B NPL Site Types, Counts, and Percent Change

Site Name	Site Type and Sub-Type	Year	Count White	Percent Change White	Count Non-White	Percent Change Non-White
Advanced Micro Devices, Inc.	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	3081		73	
		1970	2167	-29.67%	106	45.21%
		1980	1397	-35.53%	765	621.70%
		1990	1301	-6.87%	1128	47.45%
		2000	1722	32.36%	2305	104.34%
		2010	1592	-7.55%	2593	12.49%
Advanced Micro Devices, Inc. (Building 915)	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	6139		103	
		1970	6218	1.29%	316	206.80%
		1980	3859	-37.94%	2048	548.10%
		1990	3373	-12.59%	3145	53.56%
		2000	3468	2.82%	5348	70.05%
		2010	3253	-6.20%	5663	5.89%
Applied Materials	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	1556		45	
		1970	1052	-32.39%	77	71.11%
		1980	442	-57.98%	191	148.05%
		1990	370	-16.29%	243	27.23%
		2000	1155	212.16%	1375	465.84%
		2010	1107	-4.16%	1586	15.35%
CTS Printex, Inc.	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	2252		84	
		1970	3004	33.39%	319	279.76%
		1980	2816	-6.26%	1125	252.66%
		1990	2575	-8.56%	1218	8.27%
		2000	2343	-9.01%	1453	19.29%
		2010	2046	-12.68%	1702	17.14%
Fairchild Semiconductor Corp. (Mountain View Plant)	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	2636		282	
		1970	5077	92.60%	506	79.43%
		1980	4372	-13.89%	1877	270.95%
		1990	5035	15.16%	2482	32.23%
		2000	4478	-11.06%	3553	43.15%
		2010	4123	-7.93%	4307	21.22%
Fairchild Semiconductor Corp. (South San Jose Plant)	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	89		15	
		1970	1291	1350.56%	61	306.67%
		1980	3580	177.30%	753	1134.43%
		1990	4112	14.86%	1382	83.53%
		2000	4009	-2.50%	2292	65.85%
		2010	3392	-15.39%	2551	11.30%
Hewlett-Packard (620-640 Page Mill	Manufacturing/ Processing/Maintenance;	1960	3018		305	
		1970	3343	10.77%	352	15.41%
		1980	3239	-3.11%	605	71.88%

Road)	Electronic/electrical equipment	1990	3657	12.91%	1024	69.26%
		2000	2436	-33.39%	966	-5.66%
		2010	2233	-8.33%	1264	30.85%
Intel Corp. (Mountain View Plant)	Manufacturing/Processing/Maintenance; Electronic/electrical equipment	1960	2636		282	
		1970	5077	92.60%	506	79.43%
		1980	4372	-13.89%	1877	270.95%
		1990	5035	15.16%	2482	32.23%
		2000	4478	-11.06%	3553	43.15%
		2010	4123	-7.93%	4307	21.22%
Intel Corp. (Santa Clara III)	Other; Research, development, and testing facility	1960	1675		40	
		1970	1382	-17.49%	83	107.50%
		1980	826	-40.23%	272	227.71%
		1990	715	-13.44%	360	32.35%
		2000	1142	59.72%	1198	232.78%
		2010	1099	-3.77%	1364	13.86%
Intel Magnetics	Manufacturing/Processing/Maintenance; Electronic/electrical equipment, Multiple, Other	1960	1572		38	
		1970	1437	-8.59%	85	123.68%
		1980	759	-47.18%	355	317.65%
		1990	666	-12.25%	442	24.51%
		2000	1135	70.42%	1406	218.10%
		2010	1081	-4.76%	1625	15.58%
Intersil Inc./Siemens Components	Manufacturing/Processing/Maintenance; Electronic/electrical equipment	1960	3650		88	
		1970	7168	96.38%	275	212.50%
		1980	6165	-13.99%	821	198.55%
		1990	5393	-12.52%	1368	66.63%
		2000	4429	-17.88%	3078	125.00%
		2010	3541	-20.05%	4424	43.73%
Jasco Chemical Corp.	Manufacturing/Processing/Maintenance; Chemicals and allied products	1960	5077		277	
		1970	7319	44.16%	645	132.85%
		1980	5967	-18.47%	2183	238.45%
		1990	7057	18.27%	3665	67.89%
		2000	7241	2.61%	5172	41.12%
		2010	6867	-5.17%	6145	18.81%
Lorentz Barrel & Drum Co.	Recycling; Drums/tanks	1960	1315		33	
		1970	3188	142.43%	181	448.48%
		1980	2507	-21.36%	1954	979.56%
		1990	2816	12.33%	2053	5.07%
		2000	1890	-32.88%	2908	41.65%
		2010	1725	-8.73%	3264	12.24%
Moffett Naval Air Station	Other; Military/Other Ordinance	1960	3824		297	
		1970	5073	32.66%	524	76.43%
		1980	3956	-22.02%	1536	193.13%
		1990	5077	28.34%	2012	30.99%
		2000	3732	-26.49%	3099	54.03%

		2010	3204	-14.15%	3731	20.39%
Monolithic Memories	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	1394		43	
		1970	833	-40.24%	52	20.93%
		1980	387	-53.54%	221	325.00%
		1990	338	-12.66%	357	61.54%
		2000	1129	234.02%	1405	293.56%
		2010	989	-12.40%	1662	18.29%
National Semiconductor Corp.	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	2002		68	
		1970	2216	10.69%	177	160.29%
		1980	2257	1.85%	817	361.58%
		1990	2476	9.70%	1407	72.22%
		2000	2761	11.51%	3422	143.21%
		2010	2395	-13.26%	4486	31.09%
Raytheon Corp.	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	1270		157	
		1970	2978	134.49%	291	85.35%
		1980	2603	-12.59%	1151	295.53%
		1990	2929	12.52%	1530	32.93%
		2000	2791	-4.71%	2245	46.73%
		2010	2522	-9.64%	2640	17.59%
South Bay Asbestos Area	Waste Management; Co-disposal landfill (municipal and industrial)	1960	12489		526	
		1970	12648	1.27%	893	69.77%
		1980	13823	9.29%	5147	476.37%
		1990	13258	-4.09%	7039	36.76%
		2000	13215	-0.32%	15001	113.11%
		2010	15335	16.04%	28708	91.37%
Spectra-Physics, Inc.	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	2776		142	
		1970	5223	88.15%	734	416.90%
		1980	4538	-13.12%	1879	155.99%
		1990	5361	18.14%	2312	23.04%
		2000	4666	-12.96%	3037	31.36%
		2010	4363	-6.49%	3431	12.97%
Synertek, Inc. (Building 1)	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	917		28	
		1970	484	-47.22%	42	50.00%
		1980	95	-80.37%	30	-28.57%
		1990	79	-16.84%	45	50.00%
		2000	693	777.22%	805	1688.89%
		2010	652	-5.92%	859	6.71%
Teledyne Semiconductor	Manufacturing/ Processing/Maintenance; Electronic/electrical equipment	1960	1764		90	
		1970	3398	92.63%	482	435.56%
		1980	2946	-13.30%	1270	163.49%
		1990	3339	13.34%	1491	17.40%
		2000	2919	-12.58%	1905	27.77%
		2010	2644	-9.42%	2071	8.71%
TRW	Manufacturing/	1960	4019		76	

Microwave, Inc (Building 825)	Processing/Maintenance; Electronic/electrical equipment	1970	3438	-14.46%	173	127.63%
		1980	2028	-41.01%	1152	565.90%
		1990	1808	-10.85%	1754	52.26%
		2000	2148	18.81%	3049	73.83%
		2010	2016	-6.15%	3293	8.00%
Westinghouse Electric Corp. (Sunnyvale Plant)	Manufacturing/Processing/Maintenance; Electronic/electrical equipment	1960	6759		163	
		1970	7188	6.35%	311	90.80%
		1980	6587	-8.36%	2381	665.59%
		1990	7297	10.78%	3219	35.20%
		2000	5123	-29.79%	5567	72.94%
		2010	4869	-4.96%	6430	15.50%