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Lead Hazard Control in Henderson, Nevada: Identifying Critical Areas and the Associated Costs

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LEAD HAZARD CONTROL IN HENDERSON, NEVADA: IDENTIFYING CRITICAL AREAS AND THE ASSOCIATED COSTS

By

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ABSTRACT

Lead poisoning is a common, yet preventable childhood health problem in the United States today. Studies show statistically significant ($p < .05$) associations between higher childhood lead exposure and subsequent negative developmental outcomes. Since 1993, the U.S. Department of Housing and Urban Development (HUD) Lead Hazard Control (LHC) Grant Program has devoted more than $1 billion in funding to several cities.

This study investigated a total of n=75 homes enrolled into the Henderson Lead Hazard Control and Healthy Homes Program (HLHCHHP) from December 2013 – February 2015. A logistic regression was performed to ascertain the frequency of lead-based paint (LBP) found in homes based on the year it was constructed. Of the 75 enrolled and tested for LBP, 58 homes (77.3%) were found to contain LBP and 17 homes (22.7%) did not contain LBP. The significance value of p=0.013 shows that there was a statistically significant correlation between the year a housing unit was built and the maximum-likelihood of it containing LBP. The odds ratio (OR) = 0.917 [95% CI: 0.857, 0.982] indicated that a house was protective against LBP as a house gets newer in age.

Chi-square tests were conducted to determine association between substrates and components found with or without LBP in an effort to identify critical areas within a home. The results showed that wood and windows contained LBP more often than any other substrate and component. The costs for remediation on n=37 of the homes that underwent the construction phase of the program is also analyzed. A cost comparison analysis between interim control and full lead abatement is intended to provide guidance for limited budget allocations on LBP work in future projects.

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I could not have gotten through the entire process without any of those mentioned. I love you all.

DEDICATION

This is dedicated to my grandpa, Papa Ludy, who showed me what real strength is.

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Abatement – "…any set of measures designed to permanently eliminate lead-based paint hazards in accordance with standards established by appropriate Federal agencies. Such term includes –

(A) The removal of lead-based paint and lead-contaminated dust, the permanent containment or encapsulation of lead-based paint, the replacement of lead-painted surfaces or fixtures, and the removal or covering of lead contaminated soil; and

(B) All preparation, cleanup, disposal, and post-abatement clearance testing activities associated with such measures"

Component – "an architectural element of a dwelling unit or common area identified by type and location, such as a bedroom wall, an exterior windowsill, a baseboard in a living room, a kitchen floor, an interior windowsill in a bathroom, a porch floor, stair treads in a common stairwell, or an exterior wall." (*24 CFR 35.110*)

Friction surface – "…an interior or exterior surface that is subject to abrasion or friction, including, but not limited to, certain window, floor, and stair surfaces." (*24 CFR 35.110)*

Impact surface – "…an interior or exterior surface that is subject to damage by repeated sudden force, such as certain parts of doorframes." *(24 CFR 35.110)*

Interim controls – "…a set of measures designed to reduce temporarily human exposure or likely exposure to lead-based paint hazards, including specialized cleaning, repairs, maintenance, painting, temporary containment, ongoing monitoring of lead-based paint hazards or potential hazards and the establishment and operation of management and resident education programs.” (Title X of the Housing and Community Development Act of 1992)

Substrate – “the material directly beneath the painted surface out of which the components are constructed, including wood, drywall, plaster, concrete, brick, or metal” (*24 CFR 32.110*)

CHAPTER 1

INTRODUCTION

The Henderson Lead Hazard Control and Healthy Homes Program (HLHCHHP) is a collaborative effort between the Department of Environmental and Occupational Health (DEOH) at the University of Nevada, Las Vegas (UNLV) and the City of Henderson (COH), Neighborhood Services Division. The $2.3 million three year project was funded by the U.S. Department of Housing and Urban Development (HUD) on August 1, 2013 (Award #NVLHB0558-13), under HUD's Lead Hazard Control (LHC) grant program. Since 1993, over $1 billion in funding has been granted to several cities through HUD's LHC grant program (Strauss et al., 2005). The purpose of the community-wide lead programs sponsored by HUD is to eliminate childhood lead poisoning by providing remediation for lead hazards identified in homes.

Purpose of the Study

This study will describe the population targeted within Henderson, Nevada and will also provide an analysis on the prevalence of lead found, where the lead is located within the home in terms of substrates and components, and will also include a cost comparison, abatement versus interim control, of project bids based on the scope of work, on homes enrolled into the HLHCHHP between December 2013 and February 2015. This analysis will provide inspectors, researchers, contractors, housing experts, as well as current and future homeowners/renters insight into potential critical areas that may contain lead in older homes in Henderson. The cost comparison between interim control and lead abatement is intended to provide guidance for limited budget allocations on lead-based paint (LBP) work in future projects. This research is significant, as it has not been reported in peer-reviewed or other literature within Clark County at this time.

Background on Henderson, Nevada

The HLHCHHP grant investigates homes located within Henderson, Nevada. The population in Henderson has grown at an unprecedented rate over the past 50 years (City of Henderson, 2014). Located only seven miles from central Las Vegas, Henderson has become a prime location for many people to settle with their families. Although Spanish explorers arrived in Southern Nevada in the early 1800s, Henderson did not become an official city until 1953 (COH Department of Cultural Arts and Tourism, 2014). The city of Henderson began as an industrial community during World War II as many people came to work on Boulder Dam and in factory plants such as Basic Magnesium Incorporated.

As the population evolved, so did the residential areas. In 2010, Henderson was estimated to be approximately 107.73 square miles with 2,392 persons per square mile (U.S. Census Bureau, 2010). Henderson is the second largest city in Nevada with the population estimated to be at 270,811 (U.S. Census Bureau, 2013). Residential communities make up 51% of the land use (City of Henderson, 2014). There are an estimated 114,681 total housing units (occupied and vacant) with 9,362 homes built prior to 1979 (U.S. Census Bureau, 2014). The majority of these older homes have not been tested for lead. This project focuses on the inspection of homes within the Henderson city limits including the following eight zip codes: 89002, 89011, 89012, 89014, 89015, 89074, 89120, and 89122 (Fig.1).

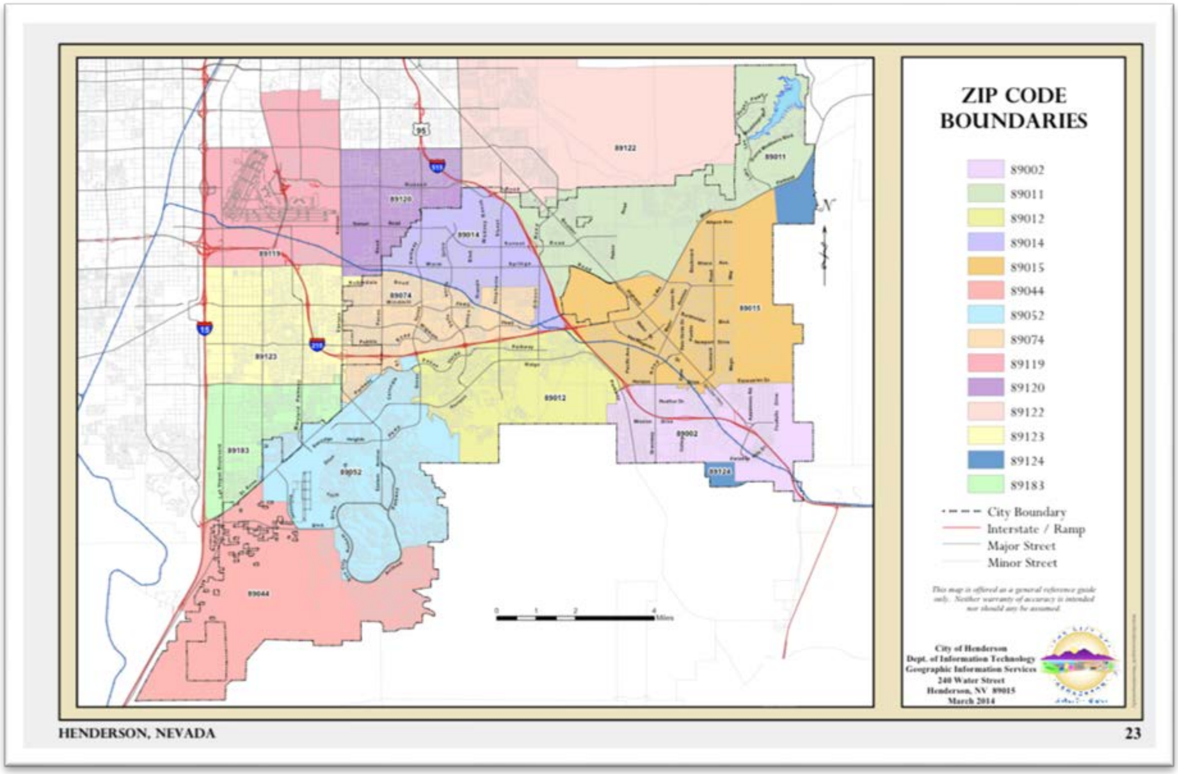


Figure 1: Map of Henderson, Nevada with zip code boundaries
(Figure source: http://www.cityofhenderson.com/docs/default-source/geographic-information-services-docs/printable-maps/miscellaneous/zip-code-boundaries.pdf?sfvrsn=2)

CHAPTER 2

LITERATURE REVIEW

What is Lead?

Lead is a natural, toxic metal that has caused extensive environmental contamination and health problems globally. It can affect multiple body systems such as the neurological, hematological, gastrointestinal, cardiovascular, and renal systems (WHO, 2010). Lead is naturally found at low levels in the Earth’s crust, mainly as lead sulfide (IARC, 2006). However, the widespread occurrence of lead in the environment is largely the result of human activity, such as mining, industrial emissions, leaded gasoline, paints, jewelry, toys, ceramics, etc. Exposure to lead is a public health concern as it may cause significant damage and even death when lead poisoned. In 2004, it resulted in 0.6% of the global burden disease and caused 143,000 deaths (WHO, 2010).

Health Effects due to Lead Exposure

Lead poisoning or elevated blood lead levels (EBLs) are a common and yet preventable childhood health problem in the U.S. today. Since 1991, the accepted level of concern for initiating a public health response had been 10 micrograms of lead per deciliter of blood (CDC, 2005). There are approximately 450,000 children in the U.S. that have blood lead levels (BLLs) higher than a lower reference value than this (CDC, 2012). In May 2012, recommendations issued by the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) were accepted by the Centers for Disease Control and Prevention (CDC) to (1) discontinue the use of the term blood lead “level of concern,” to acknowledge that there is no safe level of lead exposure, and (2) lower the reference value for the identification of children with EBLs to be 5 micrograms of lead per deciliter of blood (Burns & Gerstenberger, 2014). The current reference value is based on the

97.5th percentile of BLL concentrations among children aged between one and five years old in the U.S.; the 97.5th percentile will be re-evaluated every four years (CDC, 2012).

The adverse effects of lead poisoning have been well documented (Campbell, et al., 2011). Lead is a serious hazard for children and causes significant biological and neurological damage. Studies have shown statistically significant ($p < .05$) associations between higher childhood lead exposure and subsequent negative developmental outcomes including: lower intelligence, cognitive development, and neuropsychological performance, as well as more frequent emotional and behavioral problems (Searle et al., 2014). These detriments are strongly related to future productivity and expected earnings (Gould, 2009). One major source of lead exposure for children is LBP, which is typically found in homes constructed prior to 1978.

Prevalence of Lead in Homes

In 1999-2000 it was estimated that there were 24 million older homes in the U.S. that contained LBP, as well as associated contaminated dust and soil which all pose potential hazards (Nevin et al., 2008). HUD currently estimates that 3.8 million homes that are inhabited by children have high concentrations of lead in dust and LBP in poor condition (HUD, 2012). A significant factor to determining whether a housing unit contains LBP is the year it was constructed. LBP was banned from use in U.S. residential properties in 1978 by the U.S. Consumer Product Safety Commission (16 Code of Federal Regulations CFR 1303) (Campbell et al., 2005). Prior to 1978, lead was commonly used due to its enhanced durability and surface adherence (HUD, 2012). Lead is most commonly found in semi-gloss and enamel paint covered doors, window sills, door frames, and molding (HUD, 2012).

Although the overall level of lead exposure in the U.S. has declined over the past 30 years due to public health and housing initiatives (e.g. reducing lead content in gasoline, food canning, industrial emissions, water lead, and other sources), lead is still present in millions of homes built before 1978 (Fig. 2). Homes built before 1950 also used paint that had higher concentration of lead (HUD, 2001). Since LBP hazards are seen most often in severe, older, dilapidated housing, low socioeconomic status residents in inner cities are disproportionately affected (HUD, 2012).

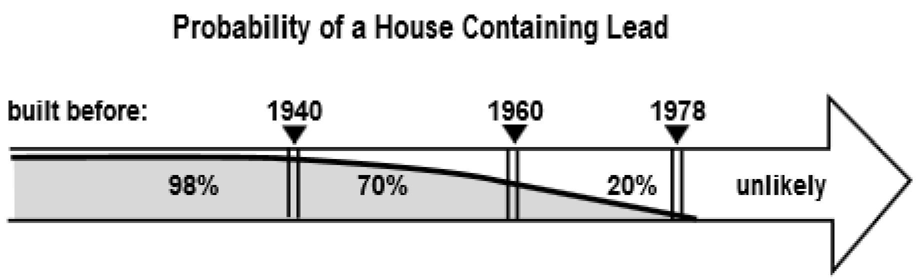


Figure 2: Likelihood of House Containing Lead by Decade
(Figure source: HUD, 2001)

Many of the homes in Henderson are one-story homes – homes where many World War II veterans, Boulder Dam workers, and factory workers resided. Due to its rich history, the City of Henderson adopted a Historic Preservation Plan for many of the surrounding town sites that are 40 years or older (these same homes have a higher risk of containing LBP) (Fig. 3). A remediation effort can be a challenge for contractors and housing specialists since many of the homes are older than 40 years of age and are protected under historical preservation laws.

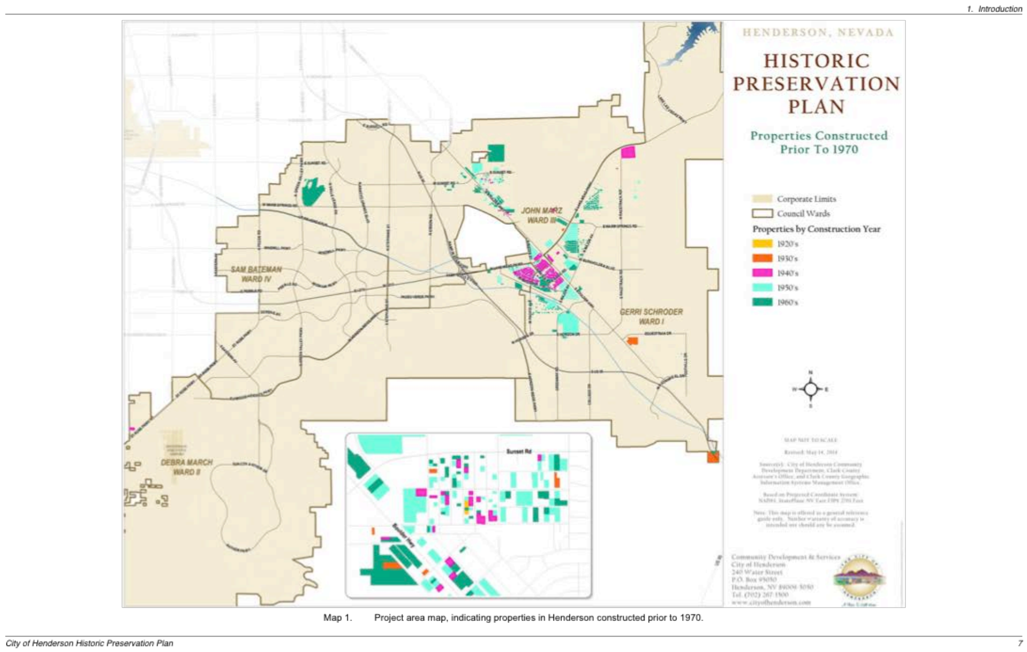


Figure 3: Map of Areas Protected under the Historic Preservation Plan (Figure source: Cityofhenderson.com, 2015)

Prevention of Lead Exposure

Residential hazards are the primary source of lead exposure for U.S. children (CDC, 2004). These hazards exist in older, deteriorating housing. A primary prevention, housing-based strategy requires that LBP hazards found within and outside of a home be identified and controlled before a child is exposed. The first approach in a primary prevention housing-based strategy is to identify a target population. A national survey found that children living in metropolitan areas and in housing built before 1946, from low-income families, and of African-American and Hispanic origin are at the highest risk for having an EBL (CDC, 2005). Communities and homes at high risk should receive focused attention and be provided with resources to eliminate or abate the LBP from their homes.

The expansion of effective primary prevention initiatives reduces the need for secondary prevention strategies (which focus on responding to children with EBLs). Federal funding for childhood lead poisoning prevention has focused primarily on secondary prevention efforts through case management of children with EBLs (CDC, 2004). When a lead poisoned child is reported to a health district or healthcare provider then treatment measures are implemented to prevent further exposure to lead. This may be a less effective prevention method as it is difficult and costly to reverse lead-associated cognitive impairment.

Furthermore, screening for children with EBLs is needed for elimination of childhood lead poisoning; however, because no level of lead found in a child is considered to be safe (CDC, 2005), and screening is not mandatory in every state, primary prevention must serve at the forefront of LHC practices. The CDC has "emphasize[d] the importance of environmental assessments to identify and mitigate hazards before children demonstrate BLLs at or higher than the reference value" (CDC, 2012). Primary prevention strategies that the CDC adopted include: reducing environmental lead exposures in soil, dust, paint, and water before children are exposed.

Lead-Based Paint Inspections and Lead Inspection Risk Assessments

As one cannot identify LBP visually, an environmental investigation to identify LBP is necessary. There are generally two types: LBP inspections and Risk Assessments. A LBP inspection, defined by HUD and the U.S. Environmental Protection Agency (EPA), is a "surface-by-surface investigation that determines the presence of LBP and the provision of a report explaining the results of the investigation" (HUD, 2012). An inspector must be certified by the EPA to conduct a LBP inspection and is the one who determines whether LBP is present. The inspector utilizes a portable X-ray Fluorescence (XRF) LBP analyzer to identify LBP and potential hazards, as defined in the Residential LBP Hazard Reduction Act of 1992 (Title X) and as defined by the EPA regulation published in the January 5, 2001 Federal Register. The portable XRF instrument exposes a building component to electromagnetic radiation in the form of X-rays or gamma radiation (HUD, 2012).

A Risk Assessment differs from the LBP inspection in that risk assessments determine the presence or absence of LBP hazards and suggest appropriate hazard control measures (HUD, 2012). A LBP hazard depends on the condition of LBP and appropriate reference standards pertaining to lead-contaminated dust and soil that "would result" in adverse human health effects (EPA, 2001). As defined by the EPA and HUD, deteriorated paint is "any exterior paint or other coating that is peeling, chipping, chalking, or cracking, or any paint or coating located on an interior or exterior surface or fixture that is otherwise damaged or separated from the substrate" (HUD, 2012). A surface area that is painted with LBP may not be considered a potential LBP hazard if the condition of the surface appears to be "intact". The appropriate EPA/HUD reference standards are as follows:

Lead-Based Paint (may be determined in either of two ways XRF or paint chip sampling)

- Surface concentration (mass of lead per area) — 1.0 µg/cm^2
- Bulk concentration (mass of lead per volume) — 0.5%, 5000 µg/g, or 5000 ppm

Dust-thresholds for Lead-Contamination

- Floors — 40 µg/ft^2

- Interior Window Sills 250 µg/ft²
- Window Troughs (clearance examination only) 400 µg/ft²

Soil-thresholds for Lead Contamination

- Play areas used by children age five or under 400 µg/g, or 400 ppm
- Other areas 1200 µg/g, or 1200 ppm

If LBP hazards are present, the inspector details which locations, building components, and substrates contain LBP hazards in their final reports (HUD, 2012).

These two procedures can each be used alone or can be combined for a full Lead Inspection Risk Assessment (LIRA). The LIRA involves a visual assessment of the property including the interior and exterior areas. It also includes dust sampling, soil sampling, and paint chip sampling when appropriate. Once LBP hazards are identified, the certified Risk Assessor provides recommendations for remediation methods to help eliminate the LBP hazards (abatement) or to temporarily stabilize them (interim controls).

Housing Characteristics and Building Conditions

Identifying environmental factors such as hazardous housing conditions, rather than using a child as a biomarker, can prevent harmful chemicals from entering children's blood at high levels. Housing characteristics are important predictors of lead hazards. The most influential variables include: building market value, year of construction, location, and property type (Strauss et al., 2005). Older homes of lower value are more likely to have LBP. Other factors that can affect an increase in hazards include the number of stories, owner-occupied status, and occasionally the zip code. In a study done on the prevalence of lead nationwide, it was shown that rental units had a slightly higher prevalence of LBP hazards at 30% compared to 23% for owner-occupied units (Jacobs et al., 2002).

Most often the hazards found in homes increase as the conditions of the house deteriorate. Once deterioration occurs, lead contaminated settled house dust may be ingested by young children. The ingestion of lead dust through frequent hand-to-mouth behavior is the most pervasive exposure pathway (Nevin et al., 2008). It is important to provide ongoing maintenance for house structures and elements of the home such as substrates and components to prevent any damage that can result in dust lead hazard contamination.

Substrates and Components

In each housing unit that is tested for LBP through HUD's LHC grant program, each substrate and component are individually analyzed by the portable XRF LBP analyzer. The substrate is the material beneath the paint. According to HUD Guidelines (2012), substrates are classified into one of six categories: brick, concrete, drywall, metal, plaster, or wood. The component of a building consists of doors, windows, walls, and so on, that are repeated in more than one room equivalent in a unit and have a common substrate (HUD, 2012). Some building component types may contain several pieces. For example, a door jamb, door stop, door frame, and door itself will collectively be considered a door.

Importance of Window Replacement

Determining which components frequently have LBP may help inspectors and/or contractors focus on specific areas when conducting a LBP inspection and/or a LIRA. Windows are critical areas to test for LBP hazards as they have the highest likelihood of containing lead paint and the highest amounts of lead dust (Dixon et al., 2012). An evaluation done on 3,000 units by HUD in 2004 showed that windows tended to have the highest LBP concentrations (Median: 2.0 μg/cm^2) of all interior surfaces; while exterior surfaces tended to have slightly higher outdoor LBP concentrations (Median of all dwellings: 2.2 μg/cm^2) (Galke et al., 2004). LBP is seen often on exterior components since LBP was originally used for durability and strong adherence. Lead used in paint was designed to withstand extreme weather conditions. However, building components that had higher LBP concentrations (such as exterior components) were also more likely to be in deteriorated condition due to age, lack of ongoing treatments and maintenance, environmental changes, as well as weatherization (Galke et al., 2004).

In a study done on the replacement of leaded windows with lead-safe windows, it was shown that a reduction in average BLL resulted from the removal of the windows (Nevin, 2007). BLLs were reduced by 4.33 ug/dL in pre-1960 housing units with LBP on interior window surfaces, whose windows were replaced (Nevin, 2007). Lead contaminated dust is more common in housing with LBP on interior window surfaces. Also, older homes are shown to have a higher average of lead loadings in dust due to friction surfaces (Nevin, 2007). If protocols involve the removal of windows with high concentrations of LBP and no other LBP was present, window removal may completely eliminate lead hazards for children currently residing in the home, as well as future children that may inhabit the home.

Economic benefits are also derived from the removal of LBP windows with safe-leaded windows. They result in increased property value, improved house appearance, and energy savings. The net economic benefit of window replacement instead of window repair varies from over $1,700 to over $2,000 per unit depending on square footage, size of housing unit, number of windows replaced, and/or market value (Dixon et al., 2012).

Lead Hazard Control Strategies & Costs

The removal of LBP varies greatly based on individual units; therefore, the costs of lead hazard control (LHC) work are non-trivial. In Gould's study (2009), she reasoned that there is no single estimate that accurately reflects either the costs or benefits of LHC. However, cost estimates exist for interim control and lead abatement (President's Task Force on Environmental Health Risks and Safety Risks to Children, 2000). Interim controls, defined by HUD Guidelines, are "…a set of measures designed to reduce temporarily human exposure or likely exposure to lead-based paint hazards, including specialized cleaning, repairs, maintenance, painting, temporary containment, ongoing monitoring of lead-based paint hazards or potential hazards and the establishment and operation of management and resident education programs" (HUD, 2012). Full lead abatement, defined by HUD Guidelines, is "…any set of measures designed to permanently eliminate LBP hazards in accordance with standards established by appropriate Federal agencies. Such term includes –

(A) The removal of lead-based paint and lead-contaminated dust, the permanent containment or encapsulation of lead-based paint, the replacement of lead-painted surfaces or fixtures, and the removal or covering of lead contaminated soil; and

(B) All preparation, cleanup, disposal, and post-abatement clearance testing activities associated with such measures" (HUD, 2012)

The President's Task Force on Environmental Health Risks and Safety Risks to Children estimated costs for lead hazard screening and interim controls to be at $1,200 per housing unit (Gould, 2009). Although interim controls are generally the cheaper LHC strategy and are shown to be effective in significantly reducing lead exposure to children in the short term, longevity of the treatment can be an issue (HUD, 2012). Some interim control methods may last up to three years or more with ongoing maintenance (HUD, 2012). The amount of time an interim control method can provide stabilization is dependent on the environment, the condition of the paint, the type of component or substrate, and/or homeowner/tenant maintenance.

Certain building components can be considered as friction and impact surfaces that can eventually deteriorate. As defined by HUD Guidelines, a friction surface is "an interior or exterior surface that is subject to abrasion or friction, including, but not limited to, certain window, floor, and stair surfaces"; whereas, an impact surface is "an interior or exterior surface that is subject to damage by repeated sudden force, such as certain parts of doorframes" (HUD, 2012). Deterioration may occur through weatherization, heat, moisture, impact, and/or friction, which may quickly reduce the efficacy of interim controls. Further, the LBP hazard is never completely eliminated through interim controls.

Abatement is more costly, but is the more desired response to LHC treatment as it provides a long-term solution that requires no monitoring of the treated surface(s). LBP abatement is expected to eliminate or reduce lead hazards for 20 years or more (HUD, 2012). Abatement is considered to be the "closest one can get to a 'permanent' solution in housing" since many commonly used building components have an expected lifespan of 20 years (HUD, 2012). The costs of individual treatments can vary depending on the region, condition of housing stock, and costs of supervision and regulation of work.

Estimating the costs for LHC projects can be identified best by a range rather than a precise estimate (Gould, 2009).

In combination, LBP inspections, LIRAs, and lead abatement work can cost up to $10,800 or more per housing unit (Gould, 2009). National averages for making a house lead-safe are approximately $7,000 per housing unit (Korfmacher, 2003). Abatement measures provide a higher margin of safety than interim controls since the effectiveness of the work is less dependent on resident action, maintenance of housing stock, the opinions and actions of property managers, and the attention of maintenance workers during repair (HUD, 2012).

Although they provide a higher margin of safety, certain abatement measures may be more invasive than others. For example, removing paint from a substrate, such as a door frame, may be the only feasible abatement option; however, paint removal may increase the level of lead in household dust and make effective cleaning difficult. Therefore, paint removal is the most invasive abatement measure. If possible, it is recommended that enclosure and building component replacement are utilized as these two approaches are the least invasive (HUD, 2012).

The types of interim control and abatement processes are listed below:

Table 1: Interim Controls & Abatement Options
(Table created using HUD Guidelines, 2012)

Lead Hazard Control Options	
Interim Controls	***Abatement***
Paint stabilization	Component Replacement
Smooth and Cleanable Surfaces	Paint Removal
Control Friction/Abrasion Points	Enclosure
Dust Removal and Control	Encapsulation
Covering/Eliminating Access to Bare Soil	Soil Removal

Each interim control and abatement method is defined, according to the Guidelines for the Evaluation and Control of LBP Hazards in Housing, published by HUD, as follows (HUD, 2012):

Interim Controls:

Paint stabilization – "the process of repainting surfaces coated with lead-based paint, which includes the proper removal of deteriorated paint and priming".

Smooth and cleanable surfaces – "minor surface damage can be corrected by spackling and recoating. If the surface has more than just minor damage it may be necessary to cover or coat the surface with a material such as metal coil stock, plastic, polyurethane, sheet vinyl, or linoleum".

Control Friction/Abrasion Points – "Friction, impact and/or chewable surfaces were identified. In order to correct the hazard contractors must review the HUD Guidelines for the Evaluation and Control of LBP Hazards in Housing manual pg. 11-34 for specific guidelines for the treatment of surfaces, such as, windows, stairs, chewable, drawers, cabinets or floors".

Dust Removal and Control – "The existing dust hazard must be removed prior to preparing the room for paint stabilization work (if paint-stabilization work is necessary). Specifically, before the plastic sheeting is laid on the floor. The deteriorated LBP coating and the underlying substrates must be stabilized and then repainted. During the cleaning phase of the project, special care must be taken to ensure that the dust is removed from the floor. This activity has the potential to create a high volume of lead-contaminated dust, and extra care must be taken by the contractor to limit and contain the dust generated".

Covering/Eliminating Access to Bare Soil – “The existing soil hazards can be addressed using any one of the following methods:

a. Soil alteration, which include surface cultivation, additives or rototilling clean soil into existing soil.

b. Soil surface cover which includes covering the soil with mulch, bark, gravel, grass and other forms of live ground cover.

c. Installing raised beds or other landscaping options.

d. Land use controls which includes can include the use of fences or planting thorny or dense bushes”.

Abatement:

Component Replacement – “Following preparation work, the deteriorated LBP coatings may be addressed by removal of the component and replacement with non-salvaged material. The use of a sprayer or atomizer will help keep the dust down during the removal process. Lead free components should be brought to the site only after all dust-generating activity is complete and the dust has been cleaned up by at one vacuuming. This remediation option has the potential to generate extremely high amounts of lead-contaminated dust and would require extensive containment”.

Paint removal – “the complete removal of lead-based paint by wet scraping, chemical stripping, or contained abrasives”.

Enclosure – “the application of rigid, durable construction materials that are mechanically fastened to the substrate to act as a barrier between LBP and the environment”.

Encapsulation – “the application of a covering or coating that acts as a barrier between LBP and the environment, the durability of which relies on adhesion and which has an expected life of at least 20 years”.

Soil Removal – **“**The existing soil hazards should be addressed using any one of the following methods:

a. Soil removal and replacement

b. Soil cultivation

c. Soil treatment (e.g. organic matter, chemical, phytoremediation) and replacement

d. Paving with concrete or asphalt”

CHAPTER 3

METHODS

Ethical considerations and Data Management

Institutional Review Board (IRB) Approval was obtained on 12/16/14 and expires on 12/15/15 under UNLV IRB Protocol #1008-3565 for data collection from the Office of Research Integrity – Human Subjects. All participants enrolled in the study provided written consent for use of their information in research. Information collected during the course of the study was stored in locked cabinets and in secure databases accessible through password protected computers; data shared with the City of Henderson was securely delivered and stored in a similar fashion. All researchers involved in data collection successfully passed certification requirements for Human Subjects Research through the Collaborative Institutional Training Initiative (CITI) Program.

The Henderson Lead Hazard Control and Healthy Homes Program

The HLHCHHP aimed to implement primary prevention activities, through its use of a housing-based strategy to target lead exposure. The HLHCHHP consisted of full-time/part-time staff members, graduate assistant students, and student workers at UNLV's DEOH, as well as staff members from the COH's Neighborhood Services Division. The division of program responsibilities can be seen in Figure 3. Shortly after the launch of the project in August 2013, staff workers created program application packets, program questionnaires, approval/denial letters, databases, procedure protocols, LIRA report templates, clearance report templates, etc. Personnel designated to conduct the LBP inspection were trained and certified through the EPA Lead Risk Assessor training courses. Risk Assessors utilizing the XRF analyzer also successfully completed the Sealed Sources Radiation Safety and DOT Training for use of the Niton XRFs as mandated by NAC 459 and according to 49CFR172.700, Subpart H, Hazmat Security Training, HM-181, and HM-126F at UNLV's Radiation Safety Office.

UNLV staff conducted the Lead Inspection Risk Assessments after qualifying a targeted housing unit. Grant employees at the COH worked in tandem with UNLV staff once the LIRA was completed and after receiving the report of the house inspection. If the unit was found to contain LBP, the COH staff members conducted a walk-through of the home and discussed LHC options with the landlord/homeowner/renter. A landlord was defined as a person or organization that rented land, a building, or an apartment to a tenant.

The Program Manager at the COH was responsible for the walk-through of the homes and created the scope of work. Once the COH determined the cost estimates of the specified work to be done, which could either be interim control or abatement, the COH staff members released bids to certified and trained contractors that were chosen to help with the construction process. The bid was then rewarded to the lowest "responsible bidder", which was the contractor who submitted the lowest price on time, without errors, and the cost was realistic aligning with appropriate work measures.

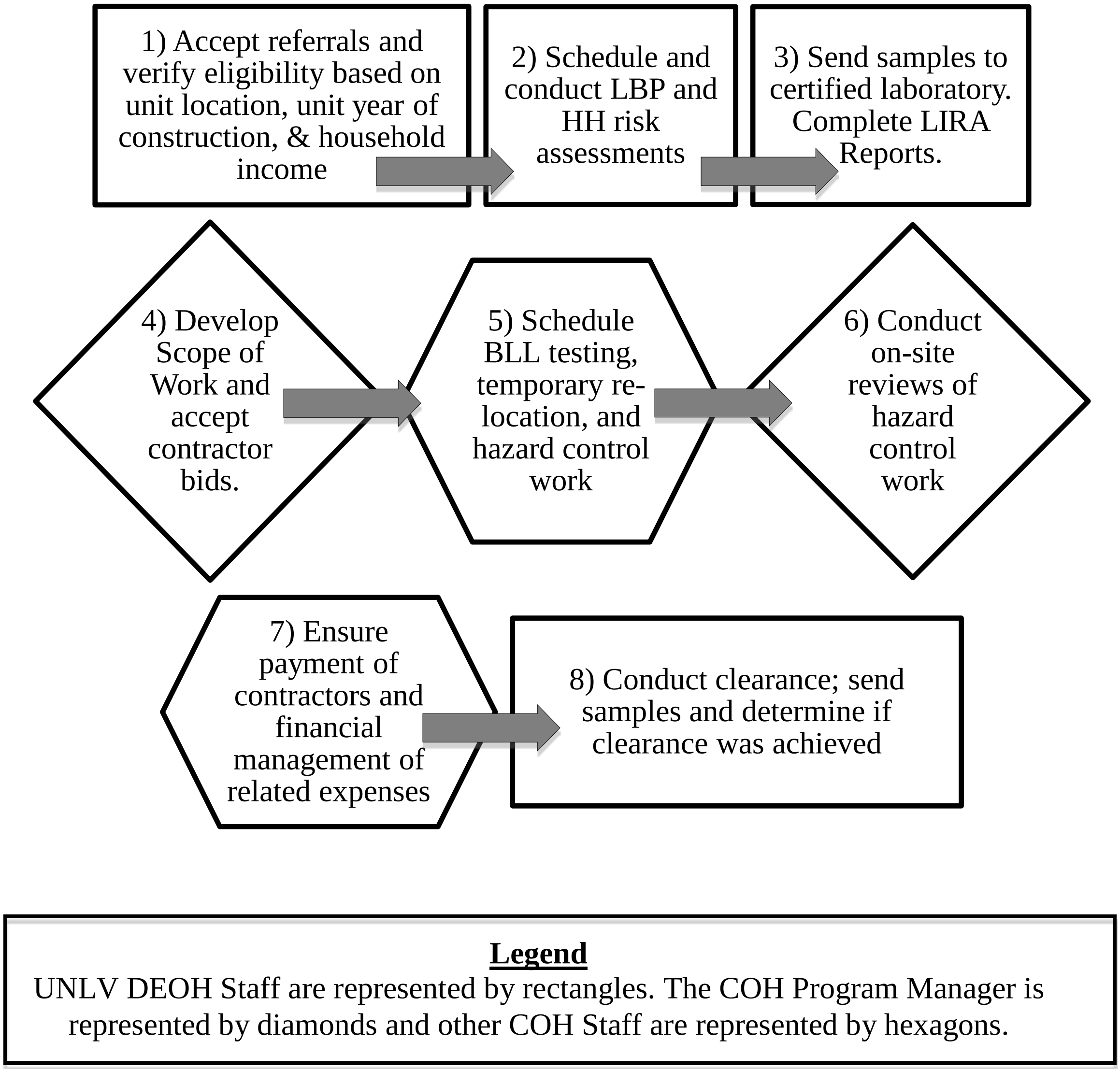


Figure 4: Flow Chart Process of Staff Position Duties for The Henderson Lead Hazard Control and Healthy Homes Program Protocol

Qualification Requirements

In order to enroll in the HLHCHHP, participants and their building must have met certain criteria established by HUD. Building conditions included a permanent, residential property confined to the city of Henderson that was built prior to 1978. Some areas, within the city of Henderson, qualified as a target population as there were over 9,000 homes that were built prior to 1978 with many families considered low-income. Occupants in the home must have met low-income household requirements (Table 1). Owner-occupied homes must have had a child under the age of 5 that resided in the home, or a child that visited up to 60 hours a year, or alternatively, could be home to an expectant mother.

Table 2: Income Requirements
(Table created using information from HUD FY 2014 Income Limits Summary)

	Number of occupants in home							
FY 2014 Income Limit Category	1	2	3	4	5	6	7	8
Very Low (50%) Income Limits	$21,550	$24,600	$27,700	$30,750	$33,250	$35,700	$38,150	$46,000
Extremely Low (30%) Income Limits	$12,950	$15,730	$19,790	$23,850	$27,910	$31,970	$36,030	$40,090
Low (80%) Income Limits	$34,450	$39,400	$44,300	$49,200	$53,150	$57,100	$61,050	$64,950

Recruitment/Outreach Efforts

An exhaustive recruitment effort was attempted involving all staff members both at UNLV and the COH. Door-to-door, businesses, elementary school raffles, social media, news and print media, as well as large community events were all targeted approaches by staff members. Recruitment efforts yielded a total of 279 pre-qualification intakes, appointments during the study production period.

Intake Process

Once a primary participant (head of household) completed a pre-qualification intake, UNLV staff scheduled an initial visit to the participant's home and mailed out an informational packet that detailed the entire process of the HLHCHHP, as well as a program application packet with additional paperwork that required each person on the lease agreement to sign. The documents in the application included: 1) Confidentiality of Social Security Numbers, 2) Agreement to HLHCHHP Terms and Conditions, 3) Rebuilding Together Conditions, and 4) Childhood Lead Testing Approval.

At the scheduled initial visit, UNLV staff collected proper documentation to enroll the family into the program. UNLV staff verified that the potential participant's house was built before 1978 (verified through the Clark County's Assessor records), had more than one bedroom, was a permanent structure, and was located within the Henderson city limits. Furthermore, for occupant eligibility, UNLV staff verified whether it was an owner or renter-occupied home, its household size, and if there were any children residing there. If it was a rental property, approval and signatures were also required from the landlord/property manager.

UNLV staff worked in collaboration with property managers to obtain necessary documents on the property itself. If there were children under five within the home, UNLV staff collected copies of each child's proof of age. Proof of age was provided through birth certificates or immunization records. UNLV staff also collected each occupant's picture identification and income documents. Income documents included any of the following: Federal 1040 (long form), W2, two most current paystubs, Supplemental Security Income (SSI), Social Security Disability Insurance (SSDI), Unemployment, or Electronic Funds Transfer (EFT). If the occupants did not work or had no documented income, they were required to fill out a self-certification form that noted that they did not receive any federal income.

Once these documents were collected and all of the paperwork was signed, UNLV staff distributed two informational and educational booklets to the homeowner/renter: 1) The Lead-Safe Certified Guide to Renovate Right (EPA) and 2) Protect Your Family From Lead In Your Home (EPA, HUD, and US Consumer Product Safety Commission). Then, UNLV staff conducted a walk-through of the home to create a map. The map described each room of the house, every door, and every window. Maps were translated into the program Microsoft Visio Drawing 2013. These maps were used for the inspection and were also incorporated into the LIRA Reports. An example of a map is provided in APPENDIX F. After occupant eligibility was verified and all documents were collected, the family was assigned a case number and a second visit to the home was scheduled for the LIRA. Out of 279 pre-qualification intakes, 77 were enrolled into the program during the study period.

Testing methods

Four types of methods were utilized by the HLHCHHP to determine lead hazards in a home. The four types were as follows:

1. Inspection of surfaces with XRF Analyzer
2. Dust sampling
3. Soil sampling
4. Paint chip sampling

The first was through the use of a Thermo Scientific Niton X-Ray Fluorescence Analyzer (XRF) that can identify LBP through several layers on varying components and substrates on the exterior and interior of a housing unit (HUD, 2012). The instrument can detect more than 25 elements and can store over 10,000 readings. In the field, a lead-certified Risk Assessor had a scribe who entered the following items into an XRF Performance Characteristic Sheet that was preloaded on an Excel spreadsheet on an Apple iPad – Location, Substrate, Component, Color, Condition (deteriorated or intact). These files were later uploaded onto a Healthy Homes server that was password-protected at UNLV. Per the XRF Performance Characteristics, any reading that was greater than or equal to 1.3 $\mu g/cm^2$ was considered to be positive for lead. Anything below 0.8 $\mu g/cm^2$ was considered to be negative, with a range of 0.8 $\mu g/cm^2$ – 1.2 $\mu g/cm^2$ considered inconclusive.

Second, dust wipe sampling on floors and windowsills using Ghost Wipes® was conducted utilizing EPA standards while following recommendations through HUD Guidelines. The Risk Assessor decided which areas were critical to test based on the program questionnaire shared with the homeowner/tenant prior to sample collection. Generally, dust samples were collected from common areas, entry ways, and in rooms where children frequently played in, ate in, and slept in. Dust wipe sampling results have been shown to correlate well with BLLs in children (Lanphear et. al, 1996).

Third, composite soil samples were collected if bare soil was present in the front as well as the back yard of the housing unit. Under Title X, only areas of bare soil are considered potential LBP hazards (HUD, 2012). The Risk Assessor had determined if the area outside of the dwelling posed to be hazardous to children that played outside.

Homeowners/tenants had to discuss any past, current, or future renovations involving landscaping or gardening. The sites included in soil sampling were: outdoor play areas, building foundation or drip line, vegetable gardens, and/or bare pathways.

Fourth, if any readings were found to be in the inconclusive range (0.8 $\mu g/cm^2$ - 1.2 $\mu g/cm^2$) and in deteriorated condition, a paint chip sample was collected. Paint chip samples were only collected after dust sampling was conducted in order to minimize cross-contamination of dust and paint samples.

Dust, soil, and paint chip samples were sent to a certified laboratory in the National Lead Laboratory Accreditation Program (NLLAP) and results were sent back to UNLV staff to analyze and be included in the LIRA reports.

Methodology

Study Design

The study design involved secondary analysis of extant data. The objective of the study was to determine the frequency of lead found in homes, where it is located within components and substrates, and to include a cost-estimate of the types of remediation used for analysis.

Research Questions, Hypotheses, and Statistical Analysis

Q1: Was the year a housing unit was built an indicator of how likely it was to contain LBP?

H_0: The year a housing unit was built was not an indicator of how likely it was to contain LBP.

H_a: The year a housing unit was built was an indicator of how likely it was to contain LBP.

Frequency was calculated for the number of homes found to contain LBP based on the year of construction. A logistic regression was used for analysis.

Q2: Was there a higher frequency of wood substrates painted with LBP, compared to other substrates in the home?

H_0: Wood was not painted with LBP more often than the other substrates.

H_a: Wood was painted with LBP more often than the other substrates.

A Chi-square test was utilized for this set of categorical data. The independent variables for the substrate test include the four categories: metal, wood, drywall, and other.

Q3: Was there a higher frequency of windows found to contain LBP, compared to other components in the home?

H_0: Windows did not contain LBP more often than the other components.

H_a: Windows did contain LBP more often than the other components.

A Chi-square test was utilized for this set of categorical data. The independent variables for components include the four categories: window, door, wall, and other.

Q4: Was there a difference between average costs of abatement methods compared to interim controls?

H_0: There was not a difference between average costs of abatement methods compared to interim controls.

H_a: There was a difference between average costs of abatement methods compared to interim controls.

Data on remediation costs was non-normally distributed; therefore, nonparametric tests were used to determine statistical significance. A Mann-Whitney U test was conducted to determine if there were differences between the two groups. A Wilcoxon signed ranks test was also conducted to determine if there were differences between the homes that had both interim controls and abatement methods used.

Expected Outcomes

There will be a higher frequency of homes containing LBP the older the house is. LBP hazards will be seen more often in wood substrates and in window components. There will be a significant difference between abatement methods and interim control pricing on homes undergoing construction.

Data collection

Databases set up by certified Lead Risk Assessors and the COH provided data points for the study. All homes and participants were de-identified. Each participant gave written consent to be included in this research study. Data collection began in December 2013. The homes enrolled in the HLHCHHP through February 2015, (sample size n=75), was considered for data analysis.

<u>Inclusion criteria</u>

1) Housing unit enrolled in HLHCHHP, within the Henderson city limits

2) Housing unit built prior to 1978

3) Homes undergoing LHC remediation, with a developed scope of work

4) All readings of tests (assays) from sampling forms of cases enrolled

Exclusion criteria

1) Homes not meeting qualifications and not enrolled in program

2) Homes tested by an environmental agency other than UNLV

3) Repeats or calibration readings from sampling forms

CHAPTER 4

STUDY FINDINGS

Data were cleaned and coded in Microsoft® Excel, 2011 and then transferred into the statistical software, IBM® SPSS® Statistics, version 21. Descriptive statistics were used to develop appropriate methods for hypotheses testing. Out of the 279 initial pre-qualification intakes, 77 cases were enrolled into the program. A sample size of n=75 was established, as two of the homes did not complete the lead inspection process within the month of February 2015. Out of the 75 observed cases, 58 homes (77.3%) were found to contain LBP and 17 homes (22.7%) did not contain LBP. Homes that underwent lead inspections ranged in years of construction from 1942 – 1977. The average age of a home inspected was 56±18 years old. There were 56 (58.9%) single family homes, 17 (17.9%) apartment units or condos, 1 duplex (1.1%), and 1 manufactured home (1.1%) tested. Of those tested, 31 (32.6%) were owner-occupied, 42 (44.2%) were rental units, and 2 (2.1%) were vacant.

The average age of a primary applicant was 40±23 years old. There was a slightly higher frequency of women applicants (n=41, 43.2%) than men (n=36, 37.9%), 78.7% of applicants were Caucasian, with 11 (11.6%) of the applicants reporting that they were of Hispanic/Latino descent. There were 32% of homes in the $15,000 - $24,999 range; the following annual income data is shown on Table 3. On average, there was at least one child residing or visiting a home, with the number of children (under age 6) in the household ranging from 1-4.

Table 3: Demographic Information (Annual Income of Household, Gender, and Race/Ethnicity for Primary Participants Enrolled (*n*=75)

VARIABLE	NO. (%)	VARIABLE	NO. (%)
Annual Income		**Gender**	
N/A	7 (9.3%)	Male	36 (37.9%)
Less than $5,000	2 (2.7%)	Female	41 (43.2%)
$5,000 - $9,999	2 (2.7%)	**Race/Ethnicity**	
$10,000 - $14,999	10 (13.3%)	Caucasian	59 (78.7%)
$15,000 - $24,999	24 (32%)	Black African American	4 (5.3%)
$25,000 - $34,999	12 (16%)	Native Hawaiian or Pacific Islander	1 (1.3%)
$35,000 - $49,999	15 (20%)	Black African American & White	1 (1.3%)
$50,000 - $74,999	2 (2.7%)	Other Multiple Race	4 (5.3%)
$75,000 - $99,999	1 (1.3%)	N/A	6 (8.0%)
Over $100,000	0		

Research Question 1 Statistical Analysis

A logistic regression was performed to ascertain the frequency of LBP found in homes based on the year it was constructed. The logistic regression model showed $\beta = -.086$, indicating that the older houses more frequently were positive for LBP. The negative slope showed a decrease of 8.6% for every year. The significance value of p=0.013 shows that there was a statistically significant correlation between the year a housing unit was built and the maximum-likelihood of it containing LBP; therefore, the null hypothesis for research question 1 was rejected. The odds ratio of the logistic regression was OR = 0.917 [95% CI: 0.857, 0.982] indicating that it was protective as a house gets newer in age.

Table 4: Logistic Regression Variables

Variables in the Equation

		B	S.E.	Wald	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Step 1[a]	Year Built	-.086	.035	6.203	.013	.917	.857	.982
	Constant	170.023	67.834	6.282	.012	6.916E+073		

Research Question 2 Statistical Analysis

For research question two, data analysis showed that a total of *n*=19,320 readings were collected from the XRF analyzer and transcribed onto the XRF Performance Characteristics Sheet. Calibration and repeat tests (assays) on surfaces were not included. Of the total readings, 10,878 (56.3%) wood substrates were tested, 2,351 (12.2%) metal substrates were tested, 3,770 (19.5%) drywall substrates were tested, and 2,321 (12%) other substrates were tested. Types of substrates included in the “other” category consisted of: brick, ceramic, concrete, plaster, plastic, porcelain, stucco, tile, and vinyl. The number of positive readings (readings equal to or greater than 1.3 $\mu g/cm^2$) totaled 833, which included 580 wood substrates, 138 metal substrates, 42 drywall substrates, and 73 other substrates.

A chi-square test for association was conducted between substrate and negative/positive readings. All expected cell frequencies were greater than five as seen in Table 5. There was a statistically significant association between substrate and negative/positive readings with $\chi^2 = 142.364$, N=19,320, df=3, $p < 0.001$; therefore, the null hypothesis was rejected.

Table 5: 4x2 Contingency Table of Positive vs Negative Substrate Readings

Substrates	Negative (No LBP) No (%)	Positive (LBP) No (%)	Total No (%)
Wood	10,298 (53.3%)	580 (3.0%)	10,878 (56.3%)
Other	2,248 (11.6%)	73 (0.4%)	2,321 (12.0%)
Metal	2,213 (11.5%)	138 (0.7%)	2,351 (12.2%)
Drywall	3,728 (19.3%)	42 (0.2%)	3,770 (19.5%)
Total	18,487 (95.7%)	833 (4.3%)	**19,320 (100.0%)**

For measuring the strength of the correlation between substrate and negative/positive readings, Cramer's V was used for the nominal level structural variables. Cramer's V was used since the number of rows and columns for the contingency table are unequal (4x2). The p value, $p<0.001$ showed a significant correlation between substrate and negative/positive readings; however Cramer's V, $V=0.086$, showed a weak association between the variables. Cramer's V values vary from 0 (no association between variables) to 1 (complete association). Since the Cramer's V value is closer to zero, it signified a weak relationship (as seen in Fig. 5) (The Political Science Department at Quinnipiac University, 2015).

Cramer's V	
.25 or higher	Very strong relationship
.15 to .25	Strong relationship
.11 to .15	Moderate relationship
.06 to .10	weak relationship
.01 to .05	No or negligible relationship

Figure 5: Crude Estimates of Cramer's V values (http://www.statisticshowto.com/how-to-compute-pearsons-correlation-coefficients/)

Research Question 3 Statistical Analysis

For research question three, the *n*=19,320 readings taken from the XRF analyzer were further analyzed. Lead Risk Assessors tested several components multiple times. For the purpose of analysis, data were abstracted, per component only. Calibration and repeat tests (assays) on surfaces were not included. Data abstraction of components resulted in a total of *n*=7,288 readings. Of the total components tested, 852 (11.7%) windows were tested, 965 (13.2%) doors were tested, 2,902 (39.8%) walls were tested, and 2,569 (35.2%) other components were tested. Types of components included in the "other" category consisted of: baseboards, cabinets, ceilings, floors, overhangs, decorative pieces, etc. The number of positive readings totaled 601, which included 179 windows, 101 doors, 79 walls, and 242 other components.

A chi-square test for association was conducted between component and negative/positive readings. All expected cell frequencies were greater than five (as seen in Table 6). There was a statistically significant association between component and negative/positive readings with $\chi^2 = 311.426$, N=7,288, df=3, $p < 0.001$; therefore, the null hypothesis is rejected. Similarly to research question 2, for measuring the strength of the correlation between component and negative/positive readings, Cramer's V was used for the nominal level structural variables.

The p value, $p<0.001$ showed a significant correlation between component and negative/positive readings and Cramer's V, $V=0.207$, showed a strong association between the variables. Cramer's V values ranging from 0.15 to 0.25 indicate a strong relationship (as seen in Fig. 5).

Table 6: 4x2 Contingency Table of Positive vs Negative Component Readings

Components	Negative (No LBP) No. (%)	Positive (LBP) No. (%)	Total No. (%)
Window	673 (79.0%)	179 (21.0%)	852 (11.7%)
Door	864 (89.5%)	101 (10.5%)	965 (13.2%)
Wall	2,823 (97.3%)	79 (2.7%)	2,902 (39.8%)
Other	2,327 (90.6%)	242 (9.4%)	2,569 (35.2%)
Total	6,687 (91.8%)	601 (8.2%)	**7,288 (100%)**

Research Question 4 Statistical Analysis

For research question 4, there were *n*=37 homes that underwent the construction phase of the program. Based on the scope of work for each home, 95 instances of remediation were identified. Of the 95 instances of remediation, 54 (56.8%) were full abatement methods and 41 (43.2%) were interim controls. The two types of interim control methods used were paint stabilization (*n*=33, 34.7%) and dust removal and control (*n*=8, 8.4%). The three types of full abatement methods used were component replacement (*n*=41, 43.2%), encapsulation (*n*=9, 9.5%), and enclosure (*n*=4, 4.2%).

Table 7: Instances of Remediation

<table>
<tr><th colspan="2">Interim Control (IC)</th><th colspan="2">Abatement (A)</th></tr>
<tr><td>Paint Stabilization</td><td>n=33, 34.7%</td><td>Component Replacement</td><td>n=41, 43.2%</td></tr>
<tr><td>Dust removal and control</td><td>n=8, 8.4%</td><td>Encapsulation</td><td>n=9, 9.5%</td></tr>
<tr><td rowspan="2">Total</td><td rowspan="2">n=41, 43.2%</td><td>Enclosure</td><td>n=4,4.2%</td></tr>
<tr><td>Total</td><td>n=54, 56.8%</td></tr>
</table>

There were 50 (52.6%) instances of remediation done on the exterior of the home, 33 (34.7%) instances of remediation done on the interior of the home, and 12 (12.6%)

instances of remediation done on both exterior and interior of the home. All of the instances describing which components, substrates, and type of remediation utilized per case are detailed in APPENDIX I. A total of $159,672 was spent on LHC work only with $88,942 spent on abatement measures and $70,730 was spent on interim controls as seen in Figure 6. The pricing per remediation ranged from $90 - $14,500.

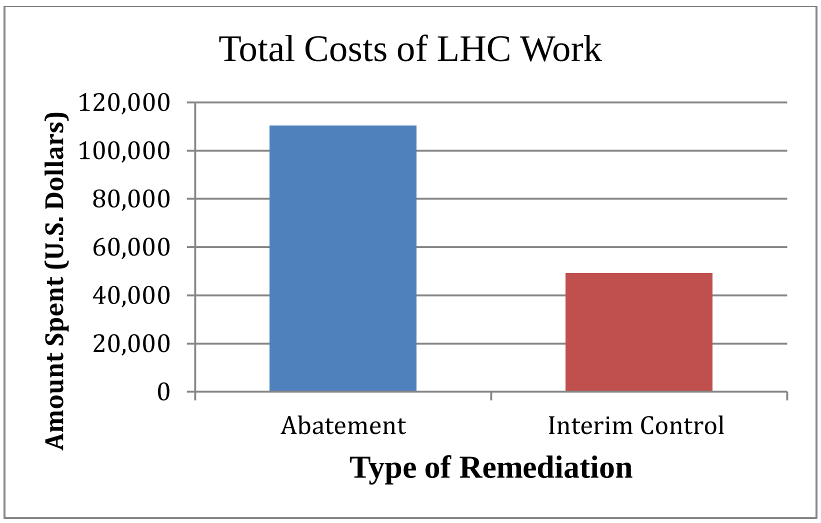


Figure 6: Total Costs of LHC Work (Abatement vs Interim Control) in U.S. Dollars

A Mann-Whitney U test was run to determine if there were differences in pricing between abatement methods and interim controls. Distributions of the pricing for abatement methods and interim controls were not similar, as assessed by visual inspection of the pyramid graph (Fig. 6). Pricing for abatement (Mean rank = 51.54) and interim controls (Mean rank = 43.34) were not significantly different, $U = 916$, $z = -1.435$, $p = .151$; therefore, the null hypothesis for question 4 for is retained – H_0: There was not a difference between average costs of abatement methods compared to interim controls.

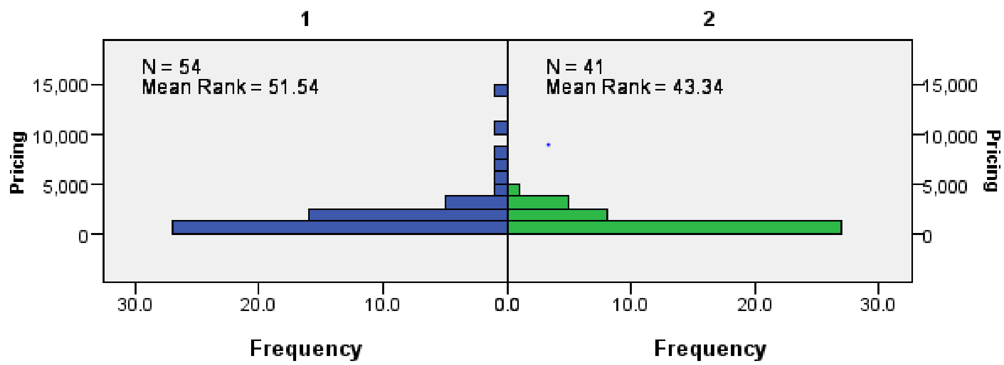


Figure 7: Pyramid Graph of Frequency for Instances of Remediation. (1= Abatement Methods, 2= Interim Controls (*n*=95))

In addition to the Mann-Whitney U test, a Wilcoxon signed rank test was run to analyze the homes that had both interim control and abatement methods used. The sample number of homes that underwent both remediation methods (interim control and abatement) were *n*=15. Pricing for abatement (Mean= $5,104) and interim controls (Mean= $1,605) were not statistically different, *z*= -1.562, *p*=0.118; therefore, the null hypothesis is retained.

CHAPTER 5

DISCUSSION

Question 1 Results

Question 1: *Was the year a housing unit was built an indicator of how likely it was to contain LBP?*

A logistic regression was performed to test the maximum likelihood of a house containing LBP based on the year it was built. The results of the logistic regression reject the null hypothesis and accept the alternative (H_a: The year a housing unit was built was an indicator of how likely it was to contain LBP). The year a housing unit was built was a significant predictor of finding lead in a house which was expected due to evidence in previous studies. The odds ratio (OR = 0.917 [95% CI: 0.857, 0.982]) indicated that a newer house was protective against lead.

A continued focus on older housing should be a priority in monitoring potential LHC projects. Studies have shown that homes built before 1950 create the greatest risk for exposure to lead (Zierold et. al, 2007). According to the American Healthy Homes Survey, 37.1 million homes (35% of 106 million total housing units) have LBP (Cox et al., 2011). The survey showed that the incidence of LBP increases as the housing unit gets older in age, reaching 86% of homes built before 1940 (Cox et al., 2011). Although the Northeast and Midwest regions have a higher percentage of the housing stock found with LBP due to early construction years, the Southwest region have thousands of homes that have not yet undergone LBP inspections and require ongoing maintenance (Cox et. al 2011). There is a lack of research in the southwest region for LBP in housing.

Question 2 Results

Question 2: *Was there a higher frequency of wood substrates painted with LBP, compared to other substrates in the home?*

A chi-square test for association between four categories of substrates and their negative/positive readings revealed a statistically significant association rejecting the null hypothesis. This showed that finding LBP in wood substrates was less likely due to chance. However, the Cramer's V test was performed to show the strength of association for the structural variables. Results from the Cramer's V test (V=0.086, p<0.001) revealed that there was a weak, but significant correlation between substrate and negative readings.

There are not many studies on whether differences in substrates can help identify LBP hazards. This type of variable may be difficult to quantify as housing stock can vary greatly between regions. For example, stucco is used for the exterior on the majority of homes enrolled into the HLHCHHP. Stucco can tolerate moisture and expansion only up to a certain degree. It is not recommended to have stucco in areas that have heavy rain which is why it is great for homes built in the southwest region. Painted wood substrates were also tested for LBP more often than any other substrate (56.3%). However, there was only a small amount of LBP found which may affect the results of the study. It is uncertain if LBP hazards are found in the paint used for substrates such as painted tile or stone. These substrates found positive for LBP may have it on the glazed coating or in the substrate itself (Jacobs et al., 2002).

The Northeast and Midwest regions may experience heavier rain and suffer from natural disasters such as earthquakes more often than areas like Henderson; therefore, brick veneer or vinyl siding is not often used for the construction of homes in Henderson as it may be in other cities. This can also affect the outcome of the substrates tested. Furthermore, there may be a weak association as the number of negative substrates tested is significantly higher than the number of positive readings found. These results may be due to the excess amount of testing samples (assays) taken from the XRF LBP analyzer.

In sum, focus on identifying LBP should not be spent on the type of substrate used for construction, but rather the paint utilized and the condition it is in (deteriorated or intact).

Question 3 Results

Question 3: *Was there a higher frequency of windows found to contain LBP, compared to other components in the home?*

A chi-square test for association between four categories of components and their negative/positive readings revealed a statistically significant association rejecting the null hypothesis. This showed that finding LBP in windows more often than other components was less likely due to chance. The Cramer's V test was conducted to further show the strength of association for the structural variables. Results from the Cramer's V test (V=0.207, p<0.001) revealed that there was a strong association between the nominal level structural variables.

The results are similar to studies conducted on testing and remediation on homes found with LBP. For example, in a previous study, it was shown that windows and doors were the building components that had the highest prevalence of LBP regardless of the year the housing unit was constructed (Jacobs et al., 2002). Windows and doors were found to be highest in frequency for both interior and exterior surfaces (Jacobs et al., 2002). These surfaces are friction and impact surfaces that can generate high levels of lead dust and paint chips. Identifying LBP in windows in older homes that have not been renovated may help prevent a child from having elevated blood lead levels. Families renting in lower-income, older households with single-pane windows are less likely to renovate their home; therefore, children moving in and out of these homes are more likely to be at harm (Nevin et al., 2008). Proper lead-safe window replacement can protect families residing in the home over a 20-year period (Nevin et al., 2008).

Question 4 Results

Question 4: *Was there a difference between average costs of abatement methods compared to interim controls?*

A Mann-Whitney U test and a Wilcoxon Signed Ranks Test on the pricing of remediation of homes that underwent construction revealed that the distributions of the pricing and abatement methods and interim controls were not similar. The tests did not prove to be statistically significant. This outcome may be due to several factors. The data was not normally distributed; therefore, parametric tests were not suitable for analysis. The non-parametric tests revealed that there were a few significant outliers in the data that may affect the results. These outliers were due to the extreme variance of range in pricing between housing units. Abatement methods (Mean for total=$2044, SD=$2586) were shown on average to be almost twice as costly as the interim controls (Mean for total=$1203, SD=$984). Without the outliers, it is known that abatement costs tend to be higher than interim controls.

There are significant monetary benefits in addition to health benefits in lead hazard control practices as shown in studies done by the National Center for Healthy

Housing, as well as HUD, and their Office of Healthy Homes and Lead Hazard Control (Wilson et al., 2006). This evaluation revealed that six years after several grantee sites' projects had concluded the LHC treatments utilized were effective at significantly reducing environmental lead levels on floors, window sills, and window troughs (Wilson et al., 2006). Social and economic benefits are achieved with the significant reduction of hazards. In Nevin et al.'s (2008) study, it was calculated that if all pre-1960 U.S. had proper lead-safe window replacement it would yield net benefits of at least $67 billion, which does not include many other benefits pertaining to health.

The decision to abate or stabilize depends on the individual case. A cost comparison analysis between interim control and full lead abatement is intended to provide guidance for limited budget allocations on LBP work in future projects; however, it is up to the project manager, contractor, and risk assessors to decide the best option. Abatement measures may be the more costly option; however, these methods last for 20 years. Interim controls require ongoing rehabilitation, visual assessment, recurring testing (every 3-4 years depending on worsening conditions), maintenance, and repainting. Recurring rehabilitation can also lead to further dust lead hazards if not maintained properly. In 5-10 years the costs of ongoing maintenance may be greater than eliminating the lead hazard completely through abatement measures. Children are less likely to be at risk if LBP hazards were completely eliminated from the home.

Limitations

This study is not without limitations. The number of homes enrolled (n=75) is a small sample size. Studies containing small sample sizes may not result in a large enough effect size for data analysis. This is also reflected in the analysis performed on the homes that underwent construction (*n*=37). Measurements and differences of mean ranks within cost would be more indicative if at least a hundred houses had been provided remediation.

Also, the homes and families selected into the Henderson LHC program were not representative of the entire city population. Due to the pre-qualifications, the homes were not specifically chosen at random and were selected and enrolled based off criteria set by HUD Guidelines. There is also a bias in data collection as the lead inspectors were more inclined to finding LBP in order to help the families that were enrolled. Oftentimes there were barriers to enrolling an interested participant. For example, a renter may have been interested in participating; however, their landlord or property owner was not and vice versa.

Some owner-occupied homes did not have any children residing in or frequently visiting the home. Furthermore, there was a nonresponse bias as a number of applicants expressed interest, but chose not to respond after being contacted by UNLV/the COH and were dropped from the pre-qualification intake process. Due to the restriction of homes being within the city limits of Henderson, the results also cannot be generalized to housing in varying regions.

Future Considerations

Since all of the homes enrolled were built prior to 1978 and approximately 77% of the homes tested were found to have LBP hazards, it is recommended that further investigation of homes for LBP built prior to 1978 be tested. The HLHCHHP conducted a very thorough and detailed inspection of every home causing an excess of numerous readings per substrate/component/housing unit. Prior studies show that the majority of painted surfaces do not contain LBP (Jacobs et al., 2002). Streamlining the Lead Inspection Risk Assessment process may help save time and money for the lead inspectors, making it a more efficient and cost-effective procedure.

It is up to the individual Lead Risk Assessor's discretion as to what they specifically test within the home. However, at minimum, each room within the interior of a unit should have the following components tested: walls (all four major walls), ceiling, door and related trim (if present), window and related trim (if present), at least one baseboard, floor, and surfaces with deteriorated paint or friction areas. For exterior paint testing, the following components should be tested: siding (all four walls), trim (two miscellaneous, one random wall), window and related trim (one random wall), door of major entrance to building, porch and railing, and surfaces with deteriorated paint (Jacobs et al., 2002).

Original components that are in deteriorated condition are shown to more likely have LBP and should be considered as critical areas. As seen in prior studies, windows and doors are the main components to have the highest prevalence of LBP (Jacobs et al., 2002). These are friction and impact surfaces that can create further LBP hazards through generating significant levels of lead dust and paint chips.

Although substrate testing in this study has shown to have significant association, it is unsure as to whether the substrate itself is a major determinant of a LBP hazard. Further studies should focus on whether substrates such as tile are hazardous or if it is the glaze on the tile that may raise concern. In terms of cost, the President's Task Force (2000) reported that private and public expenditures for the incremental cost of LHC total approximately $230 million per year for 10 years to virtually eliminate childhood lead-poisoning and a net benefit of $890 million per year for 10 years would be gained from avoided childhood lead-poisoning cases (Jacobs et al., 2002). Further efforts in cost determination and appropriate budget allocations for incorporating lead-safe practices in housing particularly with low-income housing need to be improved.

Conclusion

Public health and housing policies have made significant improvements over the years particularly with the help of agencies such as HUD that provide funding for targeted cities; however there is still much work to be done. Policy makers should focus on implementing policies and guidelines similar to those on the east coast in older housing and require blood lead testing for children living in homes found to contain LBP. Rather than waiting for a child to be lead poisoned, monitoring of the home should take precedence. Critical areas to test in the home are windows, doors, and deteriorating wood substrates.

Lead poisoning tends to occur in families when they are unaware of the potential lead exposure in their environment. Increasing public awareness and providing proper training to those involved with LHC work on lead-safe practices will help promote and prevent child-lead poisoning as well as exposure to LBP hazards. Case management of children with elevated blood lead levels through secondary prevention can be mitigated through community-wide efforts involving programs such as the HLHCHHP; which is the basis for a primary prevention housing strategy.

APPENDIX A – IRB APPROVAL

UNLV

Biomedical IRB – Expedited Review
Modification Approved

NOTICE TO ALL RESEARCHERS:
Please be aware that a protocol violation (e.g., failure to submit a modification for any change) of an IRB approved protocol may result in mandatory remedial education, additional audits, re-consenting subjects, researcher probation, suspension of any research protocol at issue, suspension of additional existing research protocols, invalidation of all research conducted under the research protocol at issue, and further appropriate consequences as determined by the IRB and the Institutional Officer.

DATE:	January 7, 2015
TO:	**Dr. Shawn Gerstenberger**, Environmental and Occupational Health
FROM:	Office of Research Integrity – Human Subjects
RE:	Notification of IRB Action Protocol Title: **Henderson Lead Hazard Control and Healthy Homes Program** Protocol #: 1008-3565 Expiration Date: December 15, 2015

The modification of the protocol named above has been reviewed and approved.

Modifications reviewed for this action include:

- Addition of Adam Obenza to the research team.

This IRB action will not reset your expiration date for this protocol. The current expiration date for this protocol is December 15, 2015.

PLEASE NOTE:
Upon approval, the research team is responsible for conducting the research as stated in the protocol most recently reviewed and approved by the IRB, which shall include using the most recently submitted Informed Consent/Assent forms and recruitment materials. The official versions of these forms are indicated by footer which contains approval and expiration dates.

Should there be *any* change to the protocol, it will be necessary to submit a **Modification Form** through ORI - Human Subjects. No changes may be made to the existing protocol until modifications have been approved by the IRB. Modified versions of protocol materials must be used upon review and approval. Unanticipated problems, deviations to protocols, and adverse events must be reported to the ORI – HS within 10 days of occurrence.

Should the use of human subjects described in this protocol continue beyond December 15, 2015, it would be necessary to submit a **Continuing Review Request Form** 30 *days* before the expiration date. If you have questions or require any assistance, please contact the Office of Research Integrity - Human Subjects at IRB@unlv.edu or call 702-895-2794.

Office of Research Integrity – Human Subjects
4505 Maryland Parkway • Box 451047 • Las Vegas, Nevada 89154-1047
(702) 895-2794 • FAX: (702) 895-0805 • IRB@unlv.edu

APPENDIX B – CONSENT AND RELEASE OF LIABILITY FORMS

HENDERSON LEAD HAZARD CONTROL AND HEALTH HOMES PROGRAM CONSENT FORM

TITLE OF STUDY: The Henderson Lead Hazard Control and Healthy Homes Program (HLHCHHP)

INVESTIGATOR(S): Shawn L. Gerstenberger, PhD (702-895-5420), Erika Marquez MPH, Mackenzie Burns PhD, Melissa Breunig MPH, Erin Sheehy MPH, Khaye Rufin BS, Amanda Sokolowsky MPH, Jorge Bertran, Josh Huebner, Noehealani Antolin and Adam Obenza (702-895-5449).

SPONSOR: US Department of Housing and Urban Development (HUD)

Name of Participant: ______________________________

Case Number:

L	H	C	.			.			.			
				Month			*Year*			#		

__Purpose__

The Department of Environmental and Occupational Health (DEOH) at the University of Nevada, Las Vegas (UNLV) is doing a research study to improve the health and safety of Henderson, Nevada residents by identifying and addressing hazardous conditions in the home. ***UNLV's research study is part of the larger Henderson Lead Hazard Control and Healthy Homes Program (HLHCHHP) in which*** the overall condition and safety of the home will be evaluated by identifying hazards in the home related to lead poisoning, and, when applicable, home-related hazards that contribute to asthma, injury, and problems with the home itself.

The DEOH is requesting permission to use data collected from your participation in the HLHCHHP program.

Data that will be used for evaluation and publication include:

- Housing conditions (i.e. lead hazards or healthy homes hazards identified)
- Health conditions (i.e. asthma health, lead poisoning)
- Type of remediation and associated cost

Data that will __not__ be used for evaluation and publication include:

- Any identifying information (i.e. name, address, phone number)

Identifying information will be protected and not be used in publications.

If you chose __not__ to give permission to use data collected from your participation in the HLHCHHP program you may still participate in the program. Your information will be excluded from any data analysis.

__Benefits & Risks__

The benefits of allowing permission to use data collected during the HLHCCHP include assisting us in gaining a better understanding of the condition of homes in Henderson, Nevada. Collecting this data will allow us to evaluate the effectiveness of the program in reducing hazards identified in homes, gather data on housing hazards that are not remediated, and gather data that can inform federal agencies of future needs. There are minimal risk in providing consent. If you choose not to sign the consent data collected will be excluded from any publication and you may continue to participate in the HLHCCHP.

Rev. 12.17.14

Approved by the UNLV IRB. Protocol #1008-3565
Received: 12-17-14 Approved: 01-07-15 Expiration: 12-15-15

It is important to note that participation in this UNLV study is voluntary and you can withdraw at anytime. There is no penalty assessed by UNLV for those who choose not to participate. Additional benefits and risks, as well as other program requirements, of participating in the complete HLHCHHP process are discussed in the program's Terms and Conditions.

Other important things to know:

All information gathered during this study will be kept completely confidential. Data will be evaluated using case numbers instead of personal names, therefore no reference will be made in written or oral materials that could link you to this study. All records will be stored in a locked facility at UNLV for five years after completion of the study or until publication, whichever is later. After the storage time, the information gathered will be destroyed. Only researchers from UNLV and HLHCCHP counterparts at the City of Henderson will have access to the study data. You can ask questions about this study at anytime.

Questions

If you do have questions about the research, your rights as a participant, or would like more information, please contact Principal Investigator Dr. Shawn Gerstenberger at (702) 895-5420 or shawn.gerstenberger@unlv.edu. For questions regarding the rights of research subjects, or should you have any complaints or comments regarding the manner in which the study is being conducted, you may contact the **UNLV Office of Research Integrity – Human Subjects at 702-895-2794 or toll free at 877-895-2794 or via email at IRB@unlv.edu.**

Please initial one box below. Signing your name below indicates that you agree to be a participant in this study.

______ The initial indicates that I have read the above consent.

or

______ The initial indicates that the above consent was read to me by the research team member.

____

Signature of participant **Date**

____

Printed name of participant **Date**

____

Signature of person obtaining consent **Date**

____

Printed name of person obtaining consent **Date**

2

Approved by the UNLV IRB. Protocol #1008-3565
Received: 12-17-14 Approved: 01-07-15 Expiration: 12-15-15

CONSENT TO PARTICIPATE IN "HENDERSON LEAD HAZARD CONTROL AND HEALTHY HOMES" PROGRAM
AND GENERAL RELEASE OF LIABILITY

This *Consent to Participate in "Henderson Lead Hazard Control and Healthy Homes" Program and General Release of Liability* ("Release") is made by ____________________________ ("Participant") in favor of the Board of Regents of the Nevada System of Higher Education, on behalf of the University of Nevada, Las Vegas ("UNLV"), and is based on the following:

Description of Program

1. UNLV's School of Community Health Sciences has obtained a grant (the "Grant") from the U.S. Department of Housing and Urban Development (the "HUD") to identify, and in some instances correct, lead and health hazards in private homes.

2. In accordance with the Grant, and in cooperation with the City of Henderson Neighborhood Services Division ("COH"), UNLV has established a "Henderson Lead Hazard Control and Healthy Homes" ("HLHCHH") program in which UNLV students and faculty members ("UNLV Team Members") perform in-home inspections to identify hazards related to lead, asthma, injury, poisoning, and structural problems. The HLHCHH program is offered at no cost to the Participant.

3. The HLHCHH program involves three or more visits to a Participant's home over a period of 5 to 6 months.

4. During their initial visit, UNLV team members will ask the Participant to complete a program application and answer a questionnaire regarding the Participant's personal health and the condition of his or her home. During visits two and three UNLV Team Members will perform a series of inspections and tests that include the following:

    - Detection of Lead-based paint using an X-ray Fluorescence handheld device.
    - Identification of safety hazards that can lead to injury.
    - Identification of asthma triggers through a visual assessment.
    - Conduct clearance testing post remediation/abatement of lead hazards.

5. In one or more subsequent visits, UNLV Team Members will provide the Participant with an educational "tool kit" to assist the Participant in identifying safety hazards in the home. UNLV Team Members will meet with the Participant to discuss the results of their inspection and to advise the Participant on ways to reduce risks in the home.

6. Depending on available resources and funding, UNLV may assist the Participant in the correction of certain hazards found in the home, including the following:

    - Providing cleaning materials such as a mop, broom, bucket, and/or trash can with a lid.
    - Providing safety equipment such as a smoke alarm, carbon monoxide-detector, and/or fire extinguisher.

7. If the Participant meets certain financial qualification criteria, UNLV may arrange for the remediation of certain structural safety hazards in the home through the COH.

8. The HLHCHH program will *not* include tests to determine the presence of asbestos or radon gas.

Agreement and Release

Based on the foregoing, the Participant agrees as follows:

A. **Consent to Participate in the Henderson Lead Hazard Control and Healthy Homes Program.** Participant agrees to participate in the HLHCHH program and consents to the use of all information and data, including photographs, video, film and other images, obtained by UNLV Team Members for analysis and publication. Participants agree to allow UNLV, HUD and/or COH to use survey responses and other data for research on housing and health. UNLV will remove all identifying information such as names, addresses and telephone numbers prior to using data for research or publication. Each Participant will be assigned a unique identifying number, which shall be kept confidential. All information will be entered into a password protected computer and any physical data files will be secured. No personal information will be used in any reports or publications that may result from this program. UNLV will retain information acquired during this program for as long as required by State and/or Federal law and regulation.

B. **Acknowledgment of Risks of Program Participation**. The Participant acknowledges that there may be some level of discomfort that may come with home visits and answering questions about his or her home and health. If the Participant is uncomfortable answering any of the questions in this study, he or she is free to skip those questions or discontinue participation in the program. Participation is voluntary and the Participant can withdraw at any time. The Participant also acknowledges that there may be risks associated with any corrective action taken in his or her home, including the removal and replacement of building materials, the use of tools and other construction equipment. The Participant will comply with all reasonable requests made by any contractor performing work on his or her property to ensure the safety of the Participant, UNLV Team Members and others.

C. **Release of UNLV, HUD and COH**. Participant acknowledges that the inspection of his or home is not comprehensive and that additional risks may exist beyond those (if any) identified by UNLV. Participant agrees that UNLV's inspection is for research purposes only and may not be relied upon by the Participant for any reason. Participant acknowledges that risks may be identified by UNLV that do not in fact exist (a "false positive") and that UNLV may fail to observe risks that do in fact exist (a "false negative"). UNLV does not warrant the accuracy of any tests and advises the Participant to obtain independent verification of the condition of his or home by appropriately licensed professionals. If any corrective actions are proposed, work will be performed by a third party contractor. The Participant agrees that any claims arising from such work will be solely the responsibility of the third party contractor and not UNLV, HUD and/or COH. Participant releases UNLV, HUD and COH, together with their employees, agents and other representatives, from all claims, arising out of his or her participation in the Henderson Lead Hazard Control and Healthy Homes program.

I have read, understand and agree to all terms and provisions of this Release.

Signature of participant: ______________________________ Date: ________

Printed name: ____________________________________ Date: ________

Signature of person obtaining consent: ____________________ Date: ________

Printed name of person obtaining consent: _________________ Date: ________

APPENDIX C - XRF PERFORMANCE CHARACTERISTIC SHEET

Performance Characteristic Sheet

EFFECTIVE DATE: **September 24, 2004** **EDITION NO.: 1**

MANUFACTURER AND MODEL:

Make: *Niton LLC*

Tested Model: *XLp 300*

Source: ^{109}Cd

Note: This PCS is also applicable to the equivalent model variations indicated below, for the Lead-in-Paint K+L variable reading time mode, in the XLi and XLp series:

XLi 300A, XLi 301A, XLi 302A and XLi 303A.

XLp 300A, XLp 301A, XLp 302A and XLp 303A.

XLi 700A, XLi 701A, XLi 702A and XLi 703A.

XLp 700A, XLp 701A, XLp 702A, and XLp 703A.

Note: The XLi and XLp versions refer to the shape of the handle part of the instrument. The differences in the model numbers reflect other modes available, in addition to Lead-in-Paint modes. The manufacturer states that specifications for these instruments are identical for the source, detector, and detector electronics relative to the Lead-in-Paint mode.

FIELD OPERATION GUIDANCE

OPERATING PARAMETERS:

Lead-in-Paint K+L variable reading time mode.

XRF CALIBRATION CHECK LIMITS:

0.8 to 1.2 mg/cm^2 (inclusive)

The calibration of the XRF instrument should be checked using the paint film nearest 1.0 mg/cm^2 in the NIST Standard Reference Material (SRM) used (e.g., for NIST SRM 2579, use the 1.02 mg/cm^2 film).

If readings are outside the acceptable calibration check range, follow the manufacturer's instructions to bring the instruments into control before XRF testing proceeds.

SUBSTRATE CORRECTION:

For XRF results using Lead-in-Paint K+L variable reading time mode, substrate correction is not needed for:

Brick, Concrete, Drywall, Metal, Plaster, and Wood

INCONCLUSIVE RANGE OR THRESHOLD:

K+L MODE READING DESCRIPTION	SUBSTRATE	THRESHOLD (mg/cm^2)
Results not corrected for substrate bias on any substrate	Brick	1.0
	Concrete	1.0
	Drywall	1.0
	Metal	1.0
	Plaster	1.0
	Wood	1.0

1 of 3

BACKGROUND INFORMATION

EVALUATION DATA SOURCE AND DATE:

This sheet is supplemental information to be used in conjunction with Chapter 7 of the HUD *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing* ("HUD Guidelines"). Performance parameters shown on this sheet are calculated from the EPA/HUD evaluation using archived building components. Testing was conducted in August 2004 on 133 testing combinations. The instruments that were used to perform the testing had new sources; one instrument's was installed in November 2003 with 40 mCi initial strength, and the other's was installed June 2004 with 40 mCi initial strength.

OPERATING PARAMETERS:

Performance parameters shown in this sheet are applicable only when properly operating the instrument using the manufacturer's instructions and procedures described in Chapter 7 of the HUD Guidelines.

SUBSTRATE CORRECTION VALUE COMPUTATION:

Substrate correction is not needed for brick, concrete, drywall, metal, plaster or wood when using Lead-in-Paint K+L variable reading time mode, the normal operating mode for these instruments. If substrate correction is desired, refer to Chapter 7 of the HUD Guidelines for guidance on correcting XRF results for substrate bias.

EVALUATING THE QUALITY OF XRF TESTING:

Randomly select ten testing combinations for retesting from each house or from two randomly selected units in multifamily housing. Use the K+L variable time mode readings.

Conduct XRF retesting at the ten testing combinations selected for retesting.

Determine if the XRF testing in the units or house passed or failed the test by applying the steps below.

Compute the Retest Tolerance Limit by the following steps:

Determine XRF results for the original and retest XRF readings. Do not correct the original or retest results for substrate bias. In single-family housing a result is defined as the average of three readings. In multifamily housing, a result is a single reading. Therefore, there will be ten original and ten retest XRF results for each house or for the two selected units.

Calculate the average of the original XRF result and retest XRF result for each testing combination.

Square the average for each testing combination.

Add the ten squared averages together. Call this quantity C.

Multiply the number C by 0.0072. Call this quantity D.

Add the number 0.032 to D. Call this quantity E.

Take the square root of E. Call this quantity F.

Multiply F by 1.645. The result is the Retest Tolerance Limit.

Compute the average of all ten original XRF results.

Compute the average of all ten re-test XRF results.

Find the absolute difference of the two averages.

If the difference is less than the Retest Tolerance Limit, the inspection has passed the retest. If the difference of the overall averages equals or exceeds the Retest Tolerance Limit, this procedure should be repeated with ten new testing combinations. If the difference of the overall averages is equal to or greater than the Retest Tolerance Limit a second time, then the inspection should be considered deficient.

Use of this procedure is estimated to produce a spurious result approximately 1% of the time. That is, results of this procedure will call for further examination when no examination is warranted in approximately 1 out of 100 dwelling units tested.

TESTING TIMES:

For the Lead-in-Paint K+L variable reading time mode, the instrument continues to read until it is moved away from the testing surface, terminated by the user, or the instrument software indicates the reading is complete. The following table provides testing time information for this testing mode. The times have been adjusted for source decay, normalized to the initial source strengths as noted above. Source strength and type of substrate will affect actual testing times. At the time of testing, the instruments had source strengths of 26.6 and 36.6 mCi.

Testing Times Using K+L Reading Mode (Seconds)						
	All Data			Median for laboratory-measured lead levels (mg/cm^2)		
Substrate	25^{th} Percentile	Median	75^{th} Percentile	Pb < 0.25	0.25 ≤ Pb<1.0	1.0 ≤ Pb
Wood Drywall	4	11	19	11	15	11
Metal	4	12	18	9	12	14
Brick Concrete Plaster	8	16	22	15	18	16

CLASSIFICATION RESULTS:

XRF results are classified as positive if they are greater than or equal to the threshold, and negative if they are less than the threshold.

DOCUMENTATION:

A document titled *Methodology for XRF Performance Characteristic Sheets* provides an explanation of the statistical methodology used to construct the data in the sheets, and provides empirical results from using the recommended inconclusive ranges or thresholds for specific XRF instruments. For a copy of this document call the National Lead Information Center Clearinghouse at 1-800-424-LEAD.

This XRF Performance Characteristic Sheet was developed by the Midwest Research Institute (MRI) and QuanTech, Inc., under a contract between MRI and the XRF manufacturer. HUD has determined that the information provided here is acceptable when used as guidance in conjunction with Chapter 7, Lead-Based Paint Inspection, of HUD's *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing*.

APPENDIX D – SAMPLING FORM DATA

XRF Performance Characteristics Sheet (Calibration Sheet)

Case #: LHC.08.14.051	NIST SRM Used: 1.04 mg/cm3
Date: 8/20/14	Acceptable Average: 0.8-1.2 mg/cm3
Inspector Name: Khaye Rufin	Calibration Check Tolerance Used: 0.06 mg/cm3
Signature:	

First Calibration		Second Calibration		Third Calibration			
First Reading:	0.9	First Reading:	0.9	First Reading:		Time of Frist Calibrat	9:50 AM
Second Reading:	1	Second Reading:	1	Second Reading:		Time of Second Calibration:	
Third Reading:	1	Third Reading:	0.9	Third Reading:		Time of Third Calibration:	
Average:	0.966666667	Average:	0.933333333	Average:	#DIV/0!		

Retest Tolerance Limit **(use computation below)**	
Pass or Fail	

Retest Tolerance Limit Computation

	Original Results		Repeat Results	Avg per Combo	Avg Sqd	Sum of Avg Sqd	
1	0.06	1	0.05	0.055	0.003025	0.00655	Quantity "C"
2	0	2	0.01	0.005	0.000025		
3	0.01	3	0	0.005	0.000025	0.00004716	Quantity "D"
4	0	4	0	0	0	0.03204716	Quantity "E"
5	0.03	5	0.04	0.035	0.001225	0.179017206	Quantity "F"
6	0	6	0	0	0		
7	0	7	0	0	0	0.294483304	Retest Tolerance Limit
8	0	8	0	0	0		
9	0.03	9	0	0.015	0.000225		
10	0.01	10	0.08	0.045	0.002025		
	Avg Original Results		Avg Repeat Results	Difference in Avgs			
	0.014		0.018	-0.004			
				If negative, multiply by -1			
				0.004			

The absolute difference must be less than the Retest Tolerance Limit to pass. If the absolute difference of overall averages is equal or greater than the Retest Tolerance Limit, then the procedure must be repeated with 10 new testing combinations. Two failures indicates that the inspection is deficient.

APPENDIX E - XRF LBP TESTING RESULTS

PAINT SAMPLING

Sample #	Location	Substrate (brick (Br), concrete (C), drywall (DW), metal (M), plaster (P), or wood(W), Stucco (S), Tile (T))	Component (Door (D), Doorframe (Df), Doorstop (Ds), Doorjamb (Dj), Windowsill (Ws), Windowframe (Wf), Baseboard (Bb), Closet (Cl), Cabinet (Cb))	Color (white (Wh), yellow (Y), red (R), black (Bl), gray (Gr), cream (Cr), brown (Brw), blue (Blu), orange (Or))	Condition	Reading	Pos/Neg	Area (sq. ft.)	Is Area Small? (Y or N)	Prob. Cause(s) of Deterior. (moisture (Mo), mildew (Ml), friction (F) or impact (I), heat (H), substrate damage (SD))	Friction (F) or Impact (I) Surface	Visible Teeth Marks (Y or N)	Calib/Rep/Notes
1	A Exterior	Wood	Doorstop	Brown	D	0							R1
2	A Exterior	Wood	Outer Door Jamb	Brown	D	0							
3	A Exterior	Wood	Door	Brown	D	0							
4	A Exterior	Wood	Door Frame	Brown	D	0.01							
5	A Exterior	Wood	Carport post near house	Brown	D	12.8	Positive	40	N	Moisture	I	N	
6	A Exterior	Wood	Carport post 1	Brown	D	0							
7	A Exterior	Wood	Carport post 1.2	Brown	D	0							
8	A Exterior	Wood	Carport post 2	Brown	D	9.3	Positive	40	N	Moisture	I	N	
9	A Exterior	Wood	Carport post 3	Brown	D	2.7	Positive	40	N	Moisture	I	N	
10	A Exterior	Wood	Carport post 4	Brown	D	22.2	Positive	40	N	Moisture	I	N	
11	A Exterior	Stucco	AWAll	White	D	0							
12	A Exterior	Concrete	Foundation	White	D	0							
13	A Exterior	Concrete	Carport Floor	Tan	D	0							
14	A Exterior	Stucco	Awall	White	D	0							
15	A Exterior	Wood	Carport Support Beam 1 interior	Brown	D	11.8	Positive	40	N	Moisture	I	N	
16	A Exterior	Wood	Cross Beam 1	Brown	D	11.5	Positive	40	N	Moisture	I	N	
17	A Exterior	Wood	Cross support	Brown	D	6.1	Positive	40	N	Moisture	I	N	
18	A Exterior	Wood	Carport Overhang	Brown	D	8	Positive	400	N	Moisture	I	N	
19	A Exterior	Wood	Decorative Support	Brown	D	8	Positive	5	Y	Moisture	I	N	
20	A Exterior	Wood	AWall Panel	Brown	D	0							
21	A Exterior	Wood	Awall overhang Support	Brown	D	0							
22	A Exterior	Wood	Overhang	Brown	D	0							
23	A Exterior	Wood	Facing overhang	Brown	D	0							
24	A Exterior	Wood	Support beam trim	Brown	D	0.08							
25	A Exterior	Wood	Support Beam 2	Brown	D	10.9	Positive	40	N	Moisture	I	N	
26	A Exterior	Wood	Cross Beam 2	Brown	D	6.9	Positive	40	N	Moisture	I	N	
27	A Exterior	Wood	Overhang 2	Brown	D	7.3	Positive	400	N	Moisture	I	N	
28	A Exterior	Wood	Cross Beam 3	Brown	D	3.7	Positive	40	N	Moisture	I	N	
29	A Exterior	Wood	Cross Beam 4	Brown	D	8.5	Positive	40	N	Moisture	I	N	
30	A Exterior	Wood	Overhang 3	Brown	D	9.4	Positive	400	N	Moisture	I	N	
31	A Exterior	Wood	Upper support beam	Brown	D	9.2	Positive	40	N	Moisture	I	N	
32	A Exterior	Wood	Support Beam 4	Brown	D	11.2	Positive	40	N	Moisture	I	N	
33	A Exterior	Wood	Cross Beam 5	Brown	D	11.9	Positive	40	N	Moisture	I	N	
34	A Exterior	Wood	Overhang 4	Brown	D	10.4	Positive	400	N	Moisture	I	N	
35	A Exterior	Wood	Decorative Support 4	Brown	D	6.4	Positive	5	N	Moisture	I	N	
36	A Exterior	Wood	Decorative Support 2	Brown	D	12	Positive	5	N	Moisture	I	N	
37	A Exterior	Wood	Decorative Support 3	Brown	D	13.5	Positive	5	N	Moisture	I	N	
38	A Exterior	Wood	Window 2 outer windowsill	Brown	D	5.7	Positive	12	Y	Moisture	I	N	
39	A Exterior	Wood	Window 2 inner windowsill	Brown	D	0.01							
40	A Exterior	Wood	Window 2 center windowsill	Brown	D	0							
41	A Exterior	Wood	Window 2 trim	Brown	D	6.7	Positive	12	Y	Moisture	I	N	
42	A Exterior	Wood	Window Frame	Brown	D	9.7	Positive	12	Y	Moisture	I	N	
43	A Exterior	Wood	Window 2 Inner Frame	Brown	D	3.6	Positive	12	Y	Moisture	I	N	
44	A Exterior	Wood	Window 1 Windowsill	Brown	D	0							
45	A Exterior	Wood	Window 1 Windowsill	Brown	D	0.01							
46	A Exterior	Wood	Window 1 trim	Brown	D	4.1	Positive	12	Y	Moisture	I	N	
47	A Exterior	Wood	Window 1 Frame	Brown	D	0.14							
48	A Exterior	Wood	Window1 inner trim	Brown	D	0.03							
49	A Exterior	Metal	Window 1 inner frame	Brown	D	0.01							
50	A Exterior	Wood	Window 1 center Windowsill	Brown	D	0							
51	A Exterior	Wood	Window 1 inner windowsill	Brown	D	0							
52	D Exterior	Stucco	D Wall	White	D	0							
53	D Exterior	Concrete	Foundation	White	D	0.05							
54	D Exterior	Wood	Window 8 outer windowsill	Brown	D	0.01							
55	D Exterior	Wood	Window 8 center windowsill	Brown	D	0							
56	D Exterior	Wood	Window 8 inner windowsill	Brown	D	0							R2
57	D Exterior	Wood	Window 8 frame	Brown	D	0							
58	D Exterior	Wood	Window 8 inner frame	Brown	D	0.15							

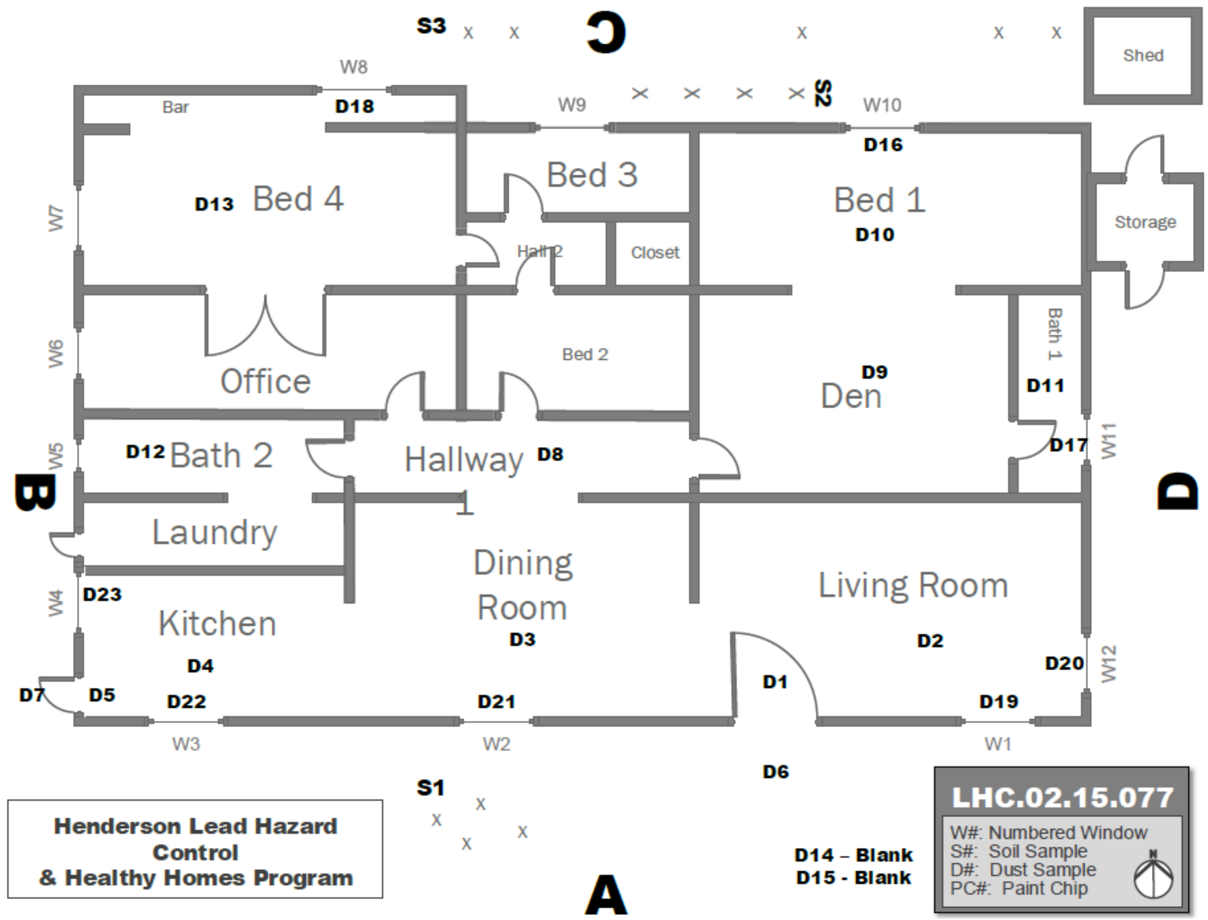
59	D Exterior	Wood	Window 8 trim	Brown	D	5.5	Positive	12	Y	Moisture	I	N	
60	D Exterior	Wood	Window divider	Brown	D	0.04							R3
61	D Exterior	Wood	Window 9 windowsill	Brown	D	0							
62	D Exterior	Wood	Window 9 center windowsill	Brown	D	0.01							
63	D Exterior	Wood	Window 9 inner windowsill	Brown	D	0.01							R4
64	D Exterior	Wood	Window 9 frame	Brown	D	0.05							R5
65	D Exterior	Wood	Window 9 inner fame	Brown	D	0.24							R6
66	D Exterior	Stucco	D Wall	White	D	0							R7
67	D Exterior	Wood	Window 7 windowsill	Brown	D	0							
68	D Exterior	Wood	Window 7 center windowsill	Brown	D	0							R8
69	D Exterior	Wood	Window 7 inner windowsill	Brown	D	0.6							
70	D Exterior	Wood	Window 7 frame	Brown	D	0.23							R9
71	D Exterior	Wood	Window 7 inner frame	Brown	D	0.08							R10
72	D Exterior	Wood	Overhang facing	Brown	D	0							
73	D Exterior	Wood	Overhang support	Brown	D	0							
74	D Exterior	Wood	Overhang	Brown	D	0							
75	D Exterior	Wood	House trim	Brown	D	0							
76	C Exterior	Stucco	C Wall	White	D	0							
77	C Exterior	Wood	Window 6 windowsill	Brown	D	0							
78	C Exterior	Wood	Window 6 frame	Brown	D	0							
79	C Exterior	Wood	Window 6 frame	Brown	D	0.27							
80	C Exterior	Wood	Window 6 inner frame	Brown	D	0.4							
81	C Exterior	Concrete	Foundation	White	D	0.01							
82	DWall	Wood	Window 7 trim	Brown	D	0.06							
83	C Exterior	Stucco	C Wall	White	D	0							
84	C Exterior	Wood	Window 5 windowsill	Brown	D	0.5							
85	C Exterior	Wood	Window 5 trim	Brown	D	0							
86	C Exterior	Wood	Window 5 frame	Brown	D	0.16							
87	C Exterior	Wood	Window 5 inner frame	Brown	D	0.09							
88	C Exterior	Metal	Window frame	Brown	D	0.22							
89	C Exterior	Wood	C wall	Brown	D	0							
90	C Exterior	Wood	Overhang	Brown	D	0							
91	C Exterior	Wood	Overhang facing	Brown	D	0							
92	C Exterior	Wood	Overhang support	Black	D	0							
93	B Exterior	Stucco	B Wall	White	D	0							
94	B Exterior	Concrete	Foundation	White	D	0.02							
95	B Exterior	Wood	Door frame	Brown	D	4.6	Positive	20	Y	Impact	Friction	N	
96	B Exterior	Wood	Door frame	Black	D	6	Positive	20	Y	Impact	Friction	N	
97	B Exterior	Wood	Outer Door Jamb	White	D	0.3							
98	B Exterior	Wood	Door step	Brown	D	1.6	Positive	4	Y	Impact	Impact	N	
99	B Exterior	Wood	Door	Black	D	0.01							
100	B Exterior	Metal	Electric box	White	D	0.07							
101	B Exterior	Metal	Pipe	White	D	0.2							
102	B Exterior	Wood	Window 3 windowsill	Brown	D	0.66							
103	B Exterior	Wood	Window 3 trim	Brown	D	5.9	Positive	12	Y	Moisture	Impact	N	
104	B Exterior	Wood	Window 3 frame	Brown	D	6.8	Positive	12	Y	Moisture	Impact	N	
105	B Exterior	Wood	Window 3 inner frame	Brown	D	4.7	Positive	12	Y	Moisture	Impact	N	
106	B Exterior	Wood	Window 3 windowsill	Brown	D	6	Positive	12	Y	Moisture	Impact	N	
107	B Exterior	Wood	Window 3 bottom piece	Brown	D	3.9	Positive	12	Y	Moisture	Impact, Friction	N	
108	B Exterior	Wood	Window 3 upper frame	Brown	D	3.6	Positive	12	Y	Moisture	Impact	N	
109	B Exterior	Metal	Pipe	White	D	0.01							
110	B Exterior	Stucco	B Wall	White	D	0							
111	B Exterior	Wood	Window 4 frame	Brown	D	6.6	Positive	12	Y	Moisture	Impact	N	
112	B Exterior	Wood	Window 4 inner frame	Brown	D	4.7	Positive	4.7	Y	Moisture	Impact	N	
113	B Exterior	Wood	Window 4 windowsill	Brown	D	0.02							
114	B Exterior	Wood	Window 4 windowsill	Brown	D	0.04							
115	B Exterior	Wood	Window 4 windowsill	Brown	D	6.5	Positive	4	Y	Moisture	Impact	N	
116	B Exterior	Wood	Window 4 center windowsill	Brown	D	0							
117	B Exterior	Wood	Window 4 inner windowsill	Brown	D	0							
118	B Exterior	Metal	Window 4 frame	Brown	D	0							
119	B Exterior	Metal	Shed	White	D	0							
120	B Exterior	Wood	Lattice	White	D	0.01							
121	B Exterior	Wood	Overhang facing	Black	D	0							
122	B Exterior	Wood	Overhang support	Black	D	0							
123	B Exterior	Wood	Overhang	Black	D	0							
124	D Exterior	Wood	Window divider	Brown	D	5.7	Positive	4	Y	Moisture	Impact	N	
125	D Exterior	Wood	Window divider	Brown	D	4.8	Positive	4	Y	Moisture	Impact	N	

126	D Exterior	Wood	Window 9 inner frame	Brown	D	1.9	Positive	12	Y	Moisture	Impact	N	
127	D Exterior	Wood	Window 9 windowsill	Brown	D	0							
128	D Exterior	Wood	Window 8 windowsill	Brown	D	0.01							
129	D Exterior	Wood	Window 9 frame	Brown	D	1.7	Positive	20	Y	Moisture	Impact	N	
130	D Exterior	Wood	Window 8 frame	Brown	D	6.1	Positive	12	Y	Moisture	Impact	N	
131	D Exterior	Wood	Window 8 inner frame	Brown	D	2.3	Positive	12	Y	Moisture	Impact	N	
132	D Exterior	Wood	Window 7 windowsill	Brown	D	0.01							
133	D Exterior	Wood	Window 7 frame	Brown	D	0.02							
134	D Exterior	Wood	Window 7 trim	Brown	D	0.05							
135	D Exterior	Wood	Window 7 sill	Brown	D	0.01							
136	D Exterior	Wood	Window 7 inner frame	Brown	D	0.7							
137	D Exterior	Wood	Window 7 inner frame	Brown	D	0.17							
138	D Exterior	Wood	Window 7 frame right	Brown	D	0.07							
139	C Exterior	Wood	Window 6 frame	Brown	D	0							
140	C Exterior	Wood	Window 6 frame right	Brown	D	1.3	Positive	12	Y	Moisture	Impact	N	
141	C Exterior	Wood	Window 6 inner frame	Brown	D	0.02							
142	C Exterior	Wood	Window 6 trim	Brown	D	0.01							
143	C Exterior	Wood	Window 6 frame upper	Brown	D	2.5	Positive	12	Y	Moisture	Impact	N	
144	C Exterior	Wood	Window 6 frame left	Brown	D	0.5							
145	C Exterior	Wood	Window 5 windowsill	Brown	D	0							
146	C Exterior	Wood	Window 5 frame	Brown	D	0.5							
147	C Exterior	Wood	Window 5 inner frame	Brown	D	0.3							
148	C Exterior	Wood	Window 5 frame	Brown	D	0.4							
149	Living Room	Wood	Door	White	D	0							
150	Living Room	Wood	Door Frame	White	D	0							
151	Living Room	Wood	Door jamb	White	D	0							
152	Living Room	Drywall	A wall	White	D	0							
153	Living Room	Wood	A wall baseboard	White	D	0.01							
154	Living Room	Tile	Entry	Cream	I	0.3							
155	Living Room	Drywall	B wall	White	I	0							
156	Living Room	Metal	Heater box	White	I	0							
157	Living Room	Wood	B wall baseboard	White	D	0							
158	Living Room	Drywall	C wall	White	D	0							
159	Living Room	Wood	C wall baseboard	White	I	0.02							
160	Living Room	Drywall	D wall	White	I	0							
161	Living Room	Wood	D wall baseboard	White	I	0.03							
162	Living Room	Wood	Window frame 7	White	I	0							
163	Living Room	Wood	Windowsill 7	White	D	0							
164	Living Room	Metal	Inner window frame 7	White	I	0							
165	Living Room	Wood	Window frame 8	White	I	0							
166	Living Room	Wood	Windowsill 8	White	D	0							
167	Living Room	Metal	Inner window frame 8	White	D	0							
168	Living Room	Wood	Window frame 1	White	I	0							
169	Living Room	Wood	Window 1 Windowsill	White	D	2.7	Positive	<2	Y	F	F,I	N	
170	Living Room	Wood	Window 8 apron	White	D	0							
171	Living Room	Wood	Window 7/8 divider	White	D	0							
172	Living Room	Metal	Inner window frame 1	White	I	0							
173	Living Room	Plastic	Wiring cover	White	I	0							
174	Living Room	Plaster	Ceiling	White	I	0							
175	Bed 1	Wood	Door	White	I	0							
176	Bed 1	Wood	Outer door frame	White	D	0							
177	Bed 1	Wood	Door stop	White	I	0							
178	Bed 1	Wood	Door jamb	White	I	0							
179	Bed 1	Wood	Inner door frame	White	D	0							
180	Bed 1	Drywall	A wall	White	I	0							
181	Bed 1	Wood	A wall baseboard	White	I	0.4							
182	Bed 1	Drywall	B wall	White	I	0							
183	Bed 1	Wood	B wall baseboard	White	I	0.3							
184	Bed 1	Drywall	C wall	White	D	0							
185	Bed 1	Wood	C wall baseboard	White	D	0.3							
186	Bed 1	Drywall	D wall	White	D	0.2							
187	Bed 1	Wood	D wall baseboard	White	D	0.5							
188	Bed 1	Wood	Closet door frame	White	I	0.29							
189	Bed 1	Wood	Closet door stop	White	I	0.2							
190	Bed 1	Drywall	Closet b wall	White	I	0							
191	Bed 1	Wood	Closet trim	White	I	0.3							
192	Bed 1	Wood	Closet rod	White	I	0							

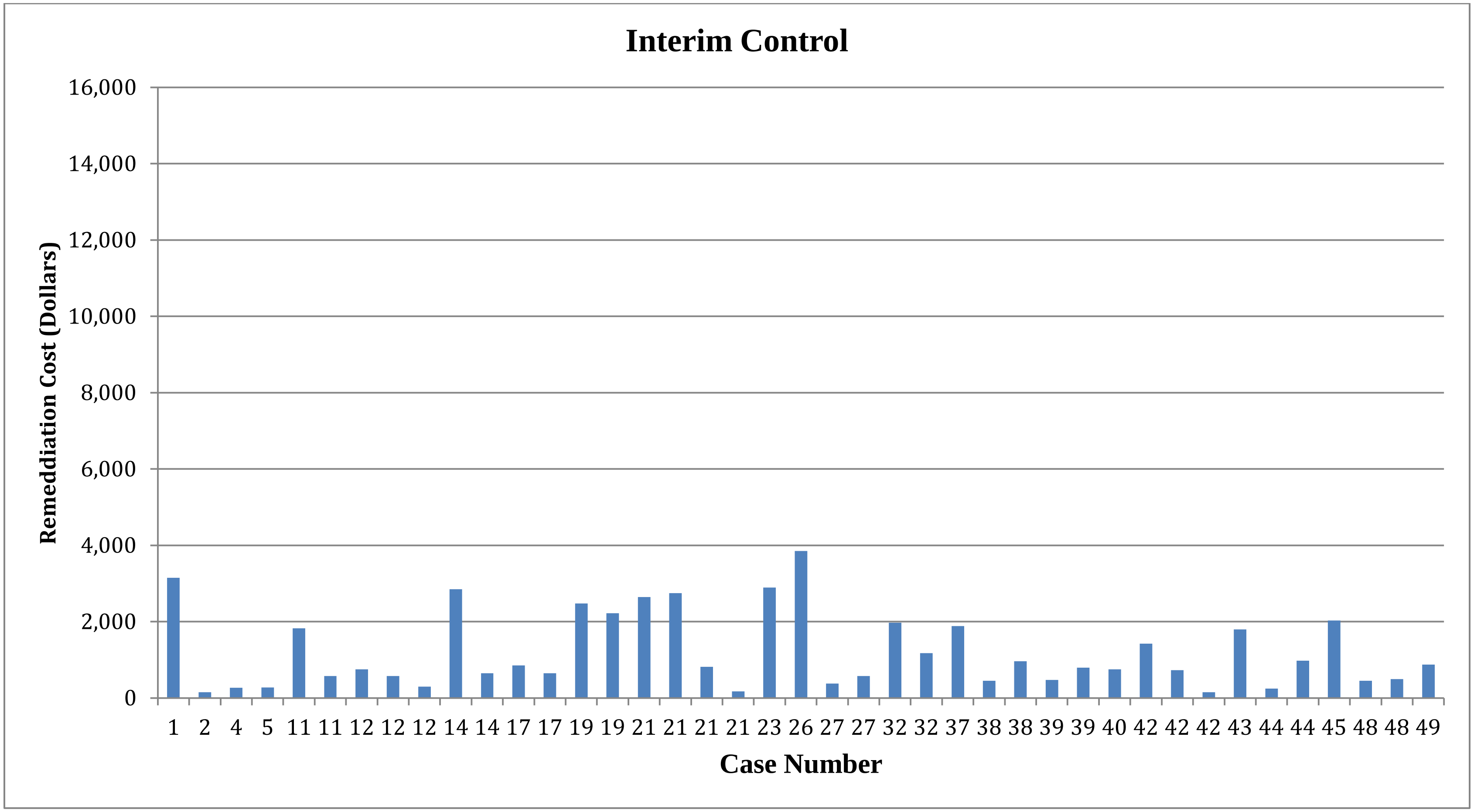
193	Bed 1	Wood	Closet shelf	White	D	0							
194	Bed 1	Wood	Closet shelf support	White	D	0.5							
195	Bed 1	Wood	Window frame 5	White	D	0.29							
196	Bed 1	Wood	Windowsill 5	White	D	0.6							
197	Bed 1	Wood	Window apron 5	White	D	0.12							
198	Bed 1	Wood	Inner window frame 5	White	D	0							
199	Bed 1	Wood	Window frame 6	White	D	0.23							
200	Bed 1	Wood	Windowsill 6	White	D	0							
201	Bed 1	Wood	Window 6 apron	White	D	0							
202	Bed 1	Metal	Inner window frame 6	White	D	0							
203	Bed 1	Plaster	Ceiling	White	D	0							
204	Hallway	Wood	Closet door	White	I	0							
205	Hallway	Wood	Outer door frame	White	I	0							
206	Hallway	Wood	Door jamb	White	I	0							
207	Hallway	Wood	Inner door jamb	White	I	0							
208	Hallway	Wood	Inner door frame	White	I	0							
209	Hallway	Wood	Closet b wall	White	D	0.7							
210	Hallway	Wood	Closet rod	White	I	0							
211	Hallway	Wood	Closet c wall	White	D	0.3							
212	Hallway	Wood	Closet shelf support	White	I	0.6							
213	Hallway	Wood	Closet shelf	White	D	0							
214	Hallway	Wood	Support	White	I	0							
215	Hallway	Wood	Divider	White	I	0.3							
216	Hallway	Wood	Entry doorstop	White	D	0.1							
217	Hallway	Wood	Entry doorframe	White	D	0.01							
218	Hallway	Wood	Top cabinet door	White	D	3.2	Positive	2	Y	F	F,I	N	R1
219	Hallway	Wood	Bottom cabinet door	White	D	1.6	Positive	2	Y	F	F,I	N	R2
220	Hallway	Wood	Top cabinet shelf	White	D	0.3							
221	Hallway	Wood	Top cabinet frame	White	D	0.17							
222	Hallway	Wood	Bottom cabinet shelf	White	D	0							
223	Hallway	Wood	Cabinet back wall	White	I	0.1							
224	Hallway	Wood	Cabinet Shelf support	White	I	0							
225	Hallway	Wood	Upper cabinet shelf support	White	D	0.5							
226	Hallway	Wood	Water heater cover	White	D	0.01							
227	Hallway	Wood	Water heater cover frame	Cream	D	0							
228	Hallway	Drywall	A wall	White	D	0							
229	Hallway	Drywall	B wall	White	D	0							
230	Hallway	Wood	C wall	White	D	0							No baseboard on D Wall.
231	Hallway	Plaster	Ceiling	White	I	0							
232	Bed 2	Wood	Door	White	D	0.02							R4
233	Bed 2	Wood	Outer door frame	White	D	0.01							
234	Bed 2	Wood	Door jamb	White	D	0							
235	Bed 2	Wood	Outer door jamb	White	D	0							
236	Bed 2	Drywall	A wall	White	D	0							R5
237	Bed 2	Wood	A wall baseboard	White	D	0							
238	Bed 2	Drywall	B wall	White	D	0							B wall baseboard inaccessible
239	Bed 2	Drywall	Windowsill 4	White	D	0							
240	Bed 2	Metal	Window frame 4	White	D	0.6							
241	Bed 2	Drywall	C wall	White	D	0							R6
242	Bed 2	Drywall	Windowsill 5	White	D	0.28							
243	Bed 2	Metal	Window frame 5	White	D	0.6							
244	Bed 2	Wood	C wall baseboard	White	D	0							
245	Bed 2	Wood	Closet shelf	White	D	0							
246	Bed 2	Drywall	D wall	White	I	0							R7
247	Bed 2	Wood	D wall baseboard	White	I	0							
248	Bed 2	Plaster	Ceiling	White	I	0							
249	Bath 1	Wood	Door	White	I	0							R8
250	Bath 1	Wood	Door stop	White	I	0							
251	Bath 1	Wood	Door jamb	White	D	0							
252	Bath 1	Wood	Outer door stop	White	I	0.01							
253	Bath 1	Wood	Door Frame	White	I	0							
254	Bath 1	Wood	Inner door frame	White	I	0							
255	Bath 1	Drywall	A wall	White	I	0.01							
256	Bath 1	Plastic	A wall splash guard	White	I	0							R9
257	Bath 1	Tile	Floor	Cream	I	0.19							
258	Bath 1	Wood	A wall baseboard	White	I	0							
259	Bath 1	Wood	Sink drawer	White	D	0							

260	Bath 1	Wood	Sink cabinet door	White	D	0							
261	Bath 1	Wood	Sink cabinet frame	White	D	0							
262	Bath 1	Ceramic	Sink	Pink	I	0							
263	Bath 1	Tile	Shower tile	White	I	5.2	Pos	10	Y				R10
264	Bath 1	Ceramic	Tub	White	D	28.5	Pos	10	Y				
265	Bath 1	Wood	Window3 frame	White	D	2.2	Pos	2	Y	Mo, mi,f	F,I	N	
266	Bath 1	Wood	Windowsill 3	White	D	0							
267	Bath 1	Wood	Outer window 3 frame	White	D	0.5							
268	Bath 1	Drywall	C wall	White	I	0							
269	Bath 1	Plastic	Splash guard	White	I	0							
270	Bath 1	Wood	C wall baseboard	White	I	0							
271	Bath 1	Drywall	D wall	White	I	0							
272	Bath 1	Wood	D wall baseboard	White	I	0							
273	Bath 1	Drywall	Ceiling	White	I	0							
274	Kitchen	Drywall	A wall	White	D	0.24							
275	Kitchen	Wood	A wall baseboard	White	I	0.02							
276	Kitchen	Drywall	B wall	White	I	0							Baseboard wall inaccessible
277	Kitchen	Wood	B wall baseboard	White	I	0							
278	Kitchen	Drywall	C wall	White	D	0							
279	Kitchen	Wood	Upper cabinet	White	D	0.02							
280	Kitchen	Wood	Sink drawer	White	I	0							
281	Kitchen	Wood	Floor	Brown	I	0.02							
282	Kitchen	Drywall	D wall	White	D	0.08							
283	Kitchen	Wood	D wall baseboard	White	D	0							
284	Kitchen	Wood	Lower sink cabinet	White	D	0							
285	Kitchen	Wood	Door	White	D	0							
286	Kitchen	Wood	Door stop	White	D	3.6	Pos	2	Y	F,I	F,I	N	
287	Kitchen	Wood	Inner door frame	White	D	0.6							
288	Kitchen	Wood	Kids chair	Red	I	0.01							
289	Kitchen	Wood	Window 2 frame	White	D	0.23							
290	Kitchen	Wood	Window 2 Windowsill	White	D	1.7	Pos	2	Y	F,I	F,I	N	
291	Kitchen	Metal	Window 2 frame	White	I	0							
292	Kitchen	Drywall	Ceiling	White	I	0.04							
293	Kitchen	Wood	Shelf divider	White	D	3.5	Pos	6	Y	F,I	F,I	N	
294	Kitchen	Wood	Shelf	White	D	1.8	Pos	8	Y	F,I	F,I	N	

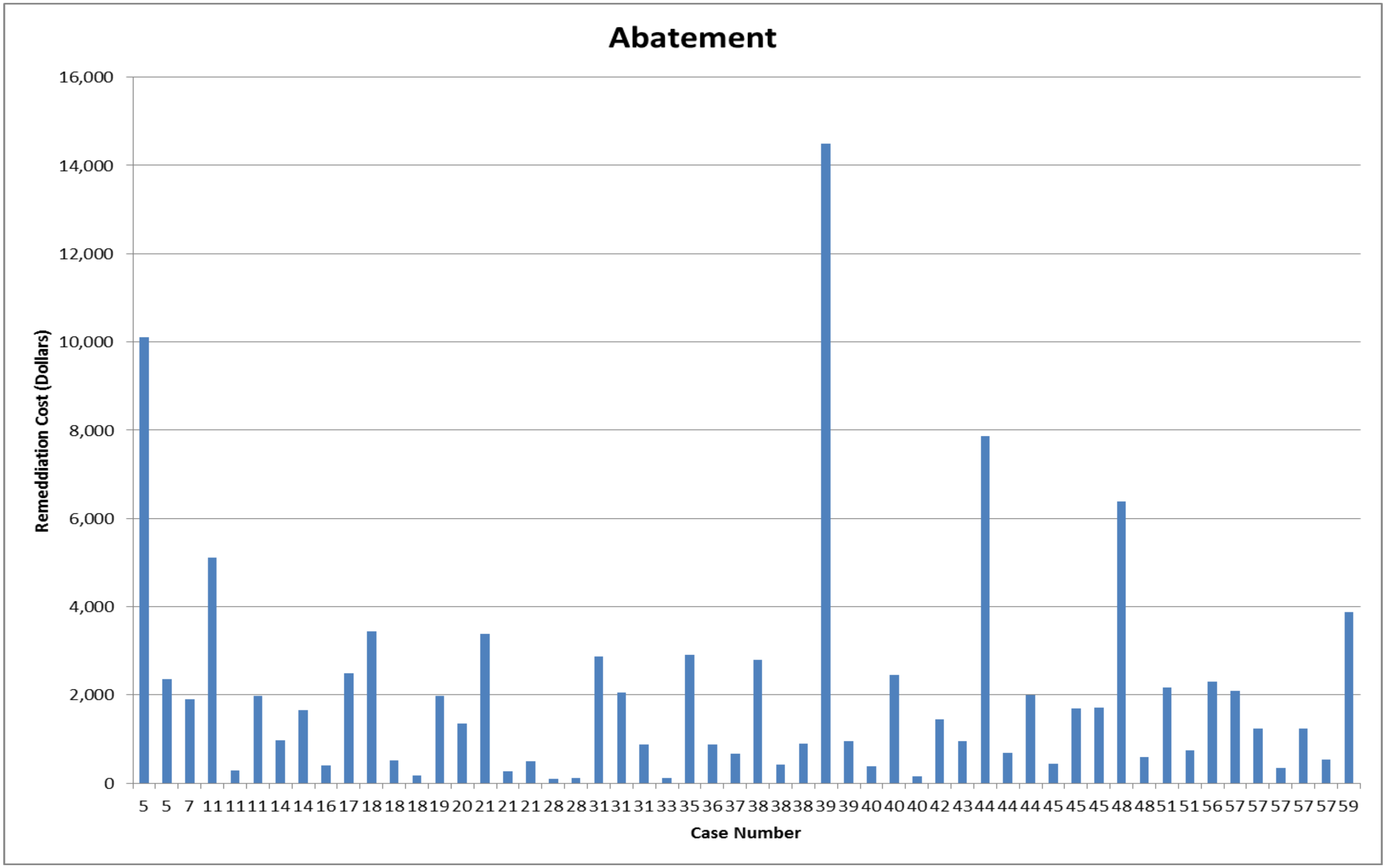
APPENDIX F – VISIO MAP OF A HOME



APPENDIX G – COSTS OF LHC WORK BY CASE: INTERIM CONTROL



APPENDIX H – COSTS OF LHC WORK BY CASE: ABATEMENT



APPENDIX I – TABLE OF REMEDIATION METHODS PER CASE

Case	Component	Substrate	Interim Control (IC) / Abatement (A)	Type	Price ($)
1	Window frames and windowsill #3, 5, 9	Wood	IC	Paint Stabilization	3,150
2	Post (exterior)	Wood	IC	Paint Stabilization	150
4	Door frame/jamb	Wood	IC	Paint Stabilization	270
5	Stucco (exterior) and new windows - 2, 3, 6, and 7	Multiple	A	Enclosure	10,105
	Doors - Bed 1, Bed 2, Hall Closet, Bathroom, and Laundry room	Multiple	A	Component Replacement	2,350
	Windowsill	Drywall	IC	Dust Removal and Control	275
7	Window frames 9, 10	Metal	A	Component Replacement	1,895
11	Windows 1, 2, 3, 4, 5, 6, 7	Wood	A	Component Replacement	5,115
	Siding	Aluminum	A	Enclosure	285
	Carport	Wood	IC	Paint Stabilization	1,825
	Bathroom ceiling, Upper and lower cabinet in Hallway near Bathroom	Multiple	IC	Paint Stabilization	575
	Doors at Bed 1, Bed 2, Hallway closet, and Bathroom	Multiple	A	Component Replacement	1,985
12	Floor	Carpet	IC	Dust Removal and Control	750
	Windows 1, 2, 5	Drywall	IC	Dust Removal and Control	575
	Post (exterior)	Metal	IC	Paint Stabilization	295
14	Exterior of car port, patio roof, fence attached to carport, all eaves and fascia/trim	Multiple	IC	Paint Stabilization	2,850
	Siding	Wood	A	Enclosure	975
	Carport floor, fence floor, backyard swim fence floor, laundry floor, both kids' rooms floor (carpet and vinyl floor tile)	Multiple	IC	Dust Removal and Control	650
	Laundry room ceiling/roof/pantry	Drywall	A	Enclosure	1,650
16	Stair case floor and platform	Concrete	A	Encapsulation	400
17	Carport, pillars, and beam	Wood	IC	Paint Stabilization	850
	Doors - Bed 2, Bed 3, Bed 4, Hall closet, Bathroom	Multiple	A	Component Replacement	2,485

	Bed 2 entire interior closet (two sides of shelf and support beams)	Multiple	IC	Paint Stabilization	650
18	Windows and frames 3, 6, 7	Metal	A	Component Replacement	3,445
	Baseboards	Wood	A	Component Replacement	525
	Door hinge	Metal	A	Component Replacement	175
19	Eaves/overhang and fascia of house	Wood	IC	Paint Stabilization	2,475
	Living Room D wall and window frame, Bed 1 entire room and closet including all base boards and ceiling, Bed 2 D wall and base boards and closet shelf, inside Hallway closet and shelf, Hallway near Bathroom B and D wall, and Kitchen door frame	Multiple	IC	Paint Stabilization	2,220
	Doors and jambs	Wood	A	Component Replacement	1,985
20	Fascia Board	Wood	A	Component Replacement	1,344
21	Windows 1, 2, 4, and 5	Wood	A	Component Replacement	3,385
	Living Room, Bed 1 (C wall only), Bed 2, both Hallways, Hall cabinet, cabinet doors, and drywall (B wall) near Bathroom	Multiple	IC	Paint Stabilization	2,648
	Door frame	Wood	A	Component Replacement	268
	Roof trim overhang, awning, support beams eaves	Wood	IC	Paint Stabilization	2,750
	Door - jambs and hardware	Wood	A	Component Replacement	495
	Floor covering	Vinyl	IC	Dust Removal and Control	819
	Windowsill 1, Windowsill 4, Windowsill 5	Drywall	IC	Dust Removal and Control	171
23	A wall stucco, B side support beams (eaves)	Stucco	IC	Paint Stabilization	2,896
26	Beams, soffit under eaves 1st and 2nd story of building, black metal stair case and railing (all metal and posts on 1st and 2nd floor)	Wood, Metal	IC	Paint Stabilization	3,850
27	Post (exterior)	Metal	IC	Paint Stabilization	375
	Windowsill 4, Floor	Drywall, Tile	IC	Dust Removal and Control	575

28	Door stop	Tile	A	Component Replacement	90
	D wall	Drywall	A	Encapsulation	118
31	Exterior black metal trim, post, and stair wells, as well as overhang eaves	Metal	A	Encapsulation	2,875
	Fascia Board	Wood	A	Component Replacement	2,050
	Stucco from exterior stair platform/overhang	Stucco	A	Component Replacement	880
32	Carport, pillars, support beams, door frame, front door entry step, all exterior exposed wood window frames	Multiple	IC	Paint Stabilization	1,975
	Living Room C wall baseboards, Hall D wall baseboards, Hall closet, entire Bed 1 closet, and entire Bed 2 closet	Multiple	IC	Paint Stabilization	1,175
33	Door stop	Tile	A	Component Replacement	125
35	Windows 4, 7, and 9	Wood	A	Component Replacement	2,903
36	Exterior stair platform/overhang	Stucco	A	Component Replacement	880
37	Window 8	Multiple	A	Component Replacement	675
	B wall and C wall of house	stucco	IC	Paint Stabilization	1,885
38	Windows 2, 3, 4, 6, 9, and 10	Wood	A	Component Replacement	2,800
	A side shutter of window 1, blue wood overhang above Window 4	Wood	IC	Paint Stabilization	450
	A wall Door	Wood	A	Component Replacement	425
	Laundry, Pantry, Hall, Bath 1, Bed 2 door frame/stop/jamb and doors as well as Bath 2 long side by side cabinets	Wood	IC	Paint Stabilization	965
	Door	Wood	A	Component Replacement	895
39	Exterior siding, window sills, frames, overhang support, upper trim, and door frames	Stucco	A	Encapsulation	14,500
	Laundry A wall, A wall divider, A wall left of door, A wall baseboard, Storage room A wall, A wall wood divider, and exterior B wall wood component where the lattice is (the B wall wood component must be	Multiple	IC	Paint Stabilization	475

	removed and replaced then repainted) corner support on B wall and entire wood carport				
	Windows 2 and 3	Wood	A	Component Replacement	950
	Kitchen door frame, Living room windowsill and frames, Kitchen, and Bed 1, 2, Hall door	Wood	IC	Paint Stabilization	795
40	Door frame	Wood	A	Component Replacement	375
	Fascia board, overhang support, and trim	Wood	A	Component Replacement	2,450
	Floor	Concrete	A	Encapsulation	165
	Carport Arch/Arch Frame	Wood	IC	Paint Stabilization	750
42	Windows 4 and 12	Multiple	A	Component Replacement	1,450
	Exterior A fascia, porch post components, and Windows 7, 8, 9, 10	Wood	IC	Paint Stabilization	1,425
	Bathroom upper and lower cabinet doors, Laundry room A wall, orange cabinets in Laundry, and Dining B wall base boards	Multiple	IC	Paint Stabilization	730
	Windowsill 4 and 11	Drywall	IC	Dust Removal and Control	155
43	Window 1	Wood	A	Component Replacement	950
	D wall stucco	Stucco	IC	Paint Stabilization	1,800
44	Windows 1, 2, 3, 8, 10, 11, 12, 13	Wood	A	Component Replacement	7,870
	Overhang and fascia board	Wood	A	Component Replacement	695
	Doors - D wall Kitchen, and Water heater room	Wood	A	Component Replacement	1,990
	Siding	Concrete	IC	Paint Stabilization	250
	Side room door frame, jamb, inner, and outer, A wall, Storage room C wall wood ledge, entire length of C wall, Bed 2 door frame, jamb, and stop	Multiple	IC	Paint Stabilization	980
45	Overhangs and dividers	Wood	IC	Paint Stabilization	2,030
	Trim (Side fascia)	Metal	A	Encapsulation	445
	C wall	Stucco	A	Component Replacement	1,690
	Fence	Wood	A	Component Replacement	1,710
48	Exterior of carport, posts, overhang, beams, cross support,	Wood	IC	Paint Stabilization	450

	of entire carport, B exterior door step				
	Windows 1, 2, 3, 4, 5, 6, 7, 8, and 9	Multiple	A	Component Replacement	6,390
	Door frame	Wood	A	Component Replacement	590
	Bath, Living room, Kitchen Windowsills/frames, Windows 1, 2, and 3, Hall upper and lower cabinet near Bath, Kitchen shelf, and dividers below the cabinets	Multiple	IC	Paint Stabilization	495
49	Overhang	Wood	IC	Paint Stabilization	875
51	Windows 2, 3, and 4	Multiple	A	Component Replacement	2,160
	Exterior A wood shutters at window 2, Concrete foundation on exterior C	Wood, Concrete	A	Encapsulation	750
56	Red painted framing around Windows 1, 7, and 8 with the garage addition, A exterior and D wall	Stucco	A	Component Replacement	2,300
57	Windows 7, 14, and 15	Multiple	A	Component Replacement	2,100
	Doors – jambs and hardware	Wood	A	Component Replacement	1,245
	White awning support posts at the laundry side of the side yard	Metal	A	Encapsulation	345
	2 Doors	Wood	A	Component Replacement	1,245
	C and D wall	Drywall	A	Encapsulation	540
59	Windows 1, 2, 4, 5, 6, and 7	Multiple	A	Component Replacement	3,880

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CURRICULUM VITAE

Graduate College
University of Nevada, Las Vegas

Khaye Gerazel Arcilla Rufin

EDUCATION

Master of Public Health
University of Nevada, Las Vegas, Nevada, 2015

- *Concentration:* Environmental & Occupational Health
- *Thesis Project:* Lead Hazard Control in Henderson, Nevada: Determining Critical Areas and the Associated Costs
- *Research Interests:* infectious diseases, toxicology, children's health, healthy housing, community sustainability, and social media disease surveillance

Post-baccalaureate Program: Biochemistry
University of Nevada, Las Vegas, Nevada, 2012

Bachelor of Science - Biological Sciences
University of Nevada, Las Vegas, Nevada, 2010

- *Minor:* Psychology

WORK EXPERIENCE

Community Gardens Steering Committee (Grow Nevada) with the Conservation District of Southern NV: June 2014 – February 2015

- *Facilitator/Social Media Coordinator/Web Support*
    - Assist the committee and head of the Community Gardens project on making the project live through social media efforts
    - Provide support through e-mail communication with members of committee
    - Aid with grant-application process
    - Assist with fundraising donations

Southern Nevada Health District (SNHD), Office of Epidemiology and Informatics: May 2014 - December 2014

- *Epidemiology Intern*
    - In charge of the investigation, proposal, and implementation of a Social Media Disease Surveillance protocol for the Southern Nevada region
    - Process involves communication with public health officials, investigators, data mining experts, law enforcement, etc. in other cities and locally to collaborate on an initial project

    - Spearheaded project involvement with Google Inc. and researchers at University of Rochester
    - Final report analysis to SNHD and UNLV internship presentations during fall semester
    - Assisted preceptor (Senior Epidemiologist) with day-to-day functions and attended meetings involving the Ebola crisis

University of Nevada, Las Vegas (UNLV), School of Community Health Sciences: March 2013 - Present

- *Graduate Research Assistant (Nov. 2013):*
    - Case Manager on Henderson Lead Hazard Control and Healthy Homes Program
        - EPA-certified Lead Risk Assessor
        - NEHA-certified Healthy Homes Specialist
        - Multi-million dollar HUD-funded grant and City of Henderson collaborated project
        - Field work consisting of lead inspections involving lead-based paint, soil, and dust sample collection, health promotion in an effort to build relationships with homeowners/landlords, renters/tenants, clearance testing after contractors conclude renovation/abatement work
        - Data collection, data management, data analysis, and final report writing
- *Graduate Research Assistant (June 2013 – Sept. 2013):*
    - Multi-million dollar funded Southern Nevada Strong grant with efforts to expand neighborhood, community, and urban sustainability
    - Ethnographic researcher
    - Field work and observation analysis in selected targeted neighborhood
    - Final report chosen as one of the sites to move forward with the project
- *Student Employee (March 2013-June 2013):*
    - Health Information Analyst
        - Center for Health Information Analysis
            - Updated the governor's hospital/health statistics report for 2012
            - Assisted in writing definitions for Personal Health Choices: 2008-2012

University Medical Center, Emergency Department, Las Vegas, NV: Sept. 2010 – Jan. 2014

- *Chief Research Assistant*
    - Research assistant on several projects in coordination with Emergency Room residents and attending physicians

    - Involved with data collection, abstraction, and analysis of specific projects
    - Community outreach – Save-A-Life event with firefighters of Las Vegas
        - CPR instructions to those in community
    - Assisted with studies in trauma
    - Abstract accepted at Western Regional Emergency Medical Conference in Long Beach (2013)
        - Presented a lightning oral PowerPoint presentation
            - "Lake Mead Emergency Medical Service Calls"
    - Promoted to Chief Research Assistant and handled administrative duties
        - Scheduling chief and management of the 32 research assistants
        - Involved with the interviewing process and selection of newly admitted research assistants to the program
        - Work alongside Director of Research Department

Robert M. Yeh, M.D., Gastroenterologist, Henderson, NV: July 2008 – Aug. 2013

- *Medical Assistant*
    - Managed all front and back desk duties
    - Appointment and surgery scheduling
    - Insurance and authorization verification for all procedures
    - Liaison for pharmaceutical companies
    - Management of internal/external referrals with various primary and specialty physicians

AWARDS AND SCHOLARSHIPS

UNLV Millennium Scholarship 2006-2010
UNLV Access Grant 2013-2015

COMMITTEE APPOINTMENTS

School of Community Health Sciences Master of Public Health Advisory Board: student representative, 2014-2016 (*appointed by Dr. Shawn Gerstenberger, Dean of School of Community Health Sciences)*

- Involvement included coordination and planning of the first MPH Assessment Summit (March 7, 2014)

Graduate Student Professional Association (GPSA) School of Community Health Sciences Representative, summer 2014

PRESENTATIONS

Western Regional Emergency Medical Conference 2013

Regional Conference – Long Beach, CA
Emergency Medical Service Activation for Drowning Incidents in Lake Mead National Recreation Area 2008-2011
Authors: Khaye Rufin, BS, Justin Sempsrott, MD, Ryan Hodnick, DO, Ross P. Berkeley, MD

ACCEPTED ABSTRACTS AND POSTERS

National Association of EMS Physicians, January 2015
Annual Meeting – New Orleans, Louisiana
Pharmacotherapy Utilization by EMS in Lake Mead National Recreation Area
Authors: Michael Holtz, MD, Ross P. Berkeley, MD, Ryan Hodnick, DO, Khaye Rufin, BS

Critical Care Transport Medicine Conference 2014
National Conference – Austin, TX
Helicopter Emergency Medical Service (HEMS) Utilization by the National Park Service in Lake Mead National Recreation Area from 2008-2011
Authors: Ryan Hodnick, DO, William Selde, MD, Kellen Galster, MD, Khaye Rufin, BS, Ross P. Berkeley, MD

4th World Conference on Drowning Prevention, Oct. 2013
International Conference – Potsdam, Germany
Emergency Medical Service Activation for Drowning Incidents in Lake Mead National Recreation Area 2008-2011
Authors: Justin Semprsott, MD, Khaye Rufin, BS, Ryan Hodnick, DO, Ross P. Berkeley, MD

PROSFESSIONAL MEMBERSHIPS
American Public Health Association *(student member)* – 2014 – present

Nevada Public Health Association *(student member)* – 2014 – present

National Environmental Health Association *(student member)* – 2014 – present

OTHER MEMBERSHIPS OR CERTIFICATIONS
Public Health Student Association (PSHA) *(Historian)*: 2014 – present

CITI Certification in the Protection of Human Research Subjects: 2010 – present

EPA-certified Lead Risk Assessor
(Certification#: NV-R-129216-1): 2014 – present

National Environmental Health Association
Healthy Homes Specialist (Certification #:20680): 2014 - present

HUMANITARIAN WORK

Rebuilding Together Southern Nevada: Feb. – May 2015

- House Team Captain
    - Oversee and manage duties for National Rebuilding Day

Rebuilding Together Southern Nevada: Feb. – May 2014

- House Team Captain
    - Part of selection process for home chosen to be adopted for renovations
    - Purchased supplies, paints, and tools necessary for National Rebuilding Day
- Volunteer Coordinator
    - Submitted e-mail blasts and announcements to obtain interested community members, leaders, and students to volunteer
    - Corresponded with volunteers directly

Lab Volunteer: Aug. 2012 – March 2013

- Assisted Dean Dr. Shawn Gerstenberger with various projects
- Involved in measuring levels of mercury contamination in captured peregrine bird feathers
- Measured levels of mercury in fetal placenta for anthropology department

Rebuilding Together Southern Nevada: April 2013

- Participation in National Rebuilding Day

Christmas in the Barrios (Save-A-Life): Dec. 2011 and Dec. 2012

- Helped with Christmas festival for the Hispanic community outreach
- Toy and Bike Giveaway for children
- Assisted firefighters with CPR training for families in attendance

Save-A-Life: 2011

- Attended fairs and helped set up booths at events in coordination with firefighters to help families and children learn how to give CPR

Ronald McDonald House: 2010

- Participated in cooking meals for families with children in hospital

International Travel - Medical Mission with Tropical Pathology and Infectious Diseases Association (TPaIDA): July 2009

- Iquitos, Peru and the Amazon Jungle
- Participated in aiding villagers through a jungle clinic, medication distribution, lectures, lab rotation, and clinical rotations with direct hospital care in Emergency Rooms, Operating Rooms, and patient bedside

Get Outdoors NV: 2007-2010

- Help cleanup areas in need around Las Vegas area including – Boulder City, Lake Mead National Recreation Area, Willow Beach, Henderson, Summerlin, Red Rock National Park

Opportunity Village: Dec. 2008

- Helped with Christmas festival activities

St. Rose Siena Volunteer: 2004-2006

- Main desk assistance
- Med surge assistance