PYRAMID LAKE HOUSING AUTHORITY TRIP REPORT
Assessment of Mold and Moisture Conditions

Final Report

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PYRAMID LAKE RESERVATION HOUSING AUTHORITY TRIP REPORT

INTRODUCTION

Elton Jones, from HUD’s Eastern Woodlands Office of Native American Programs, and Eugene Goldfarb and Paul Knight from Magna Systems, Inc. conducted a site visit at the Pyramid Lake Housing Authority (PLHA) on February 8-9, 2005. The PLHA administers the housing program for the Pyramid Lake Paiute Indian Reservation. The site visit provided technical assistance to PLHA in assessing mold and moisture conditions in housing units. This report summarizes activities and issues addressed while on site. A detailed analysis of findings and recommendations is found in PART II: Pyramid Lake Housing Authority Technical Housing Assessment Report: Examining Mold and Moisture Conditions of Homes on the Pyramid Lake Paiute Indian Reservation.

BACKGROUND INFORMATION

The Pyramid Lake Paiute Tribes' Reservation is located thirty-five miles northeast of Reno, Nevada in a remote desert area located in the counties of Washoe, Lyon, and Storey. The reservation covers 475,000 acres or 742.2 square miles. Approximately 112,000 acres cover the surface of a terminal desert lake, Pyramid Lake. Pyramid Lake, approximately 15 miles long, 11 miles wide, and measuring 350 feet at its deepest point, is one of the most valuable assets of the Tribe and is entirely enclosed within the boundaries of the Reservation.

There are 1,345 AIAN individuals that reside on or near the Reservation. The Pyramid Lake Paiute Tribe has approximately 2,050 enrolled members. The majority of enrolled Tribal members reside on the Reservation.

The average annual precipitation is 7 inches. The average August air temperature is 86 degrees while the average January air temperature is 45 degrees.

According to Ms. Jackie Mix of the PLHA, PLHA oversees approximately 208 homes, of which about 52 are Low Rent and the rest are Mutual Help.

The assessment team responded to a request from the Eastern Woodlands Office of Native American Programs to assess site and housing conditions contributing to mold and moisture problems at the Pyramid Lake Reservation. The Executive Director of PLHA requested technical assistance to address mold and moisture conditions and mold testing.

The assessment team visited two homes built over crawl spaces. One was a two-bedroom ranch, the other a three-bedroom two story style dwelling. One was heated

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with natural gas, although it used the auxiliary wood stove as the primary heat source, and the other used propane. The ages of the homes were approximately twenty-five years.

**Day 1: Monday, February 7, 2005**

Monday was a travel day.

**Day 2: Tuesday, February 8, 2005**

The assessment team arrived at the PLHA Office in Nixon, Nevada on Tuesday morning. The team met with Ms. Jackie Mix, Development Coordinator, to discuss the day’s activities, outline the team’s role while on the reservation, and address PLHA’s concerns regarding the site visit.

The PLHA selected the properties to be inspected and Jackie Mix coordinated the logistics for the site visit. Following the meeting, the assessment team inspected two homes (one low-rent and one Mutual Help) and then inspected a few homes under construction.

Digital photographs were taken to record conditions in all homes. The inspection process also involved visual assessments of both interior and exterior conditions; various measurements pertaining to infiltration, and airflow; and discussions with available residents. *PART II: Pyramid Lake Housing Authority Technical Housing Assessment Report: Examining Mold and Moisture Conditions of Homes on the Pyramid Lake Paiute Indian Reservation* provides a detailed analysis of findings and recommendations for the homes investigated on the Reservation.

**Day 3: Wednesday, February 9, 2004**

On Wednesday morning debriefing and training was provided from approximately 10 AM to 12 PM to the following members of the PLHA:

- Christine Johnson, Executive Director
- Jackie Mix, Development Coordinator
- Jackie Cawelti, Resident Services
- Jill Mix, Finance Officer
- Steve Sampson, Maintenance

The remainder of Wednesday was spent on travel.

**FINDINGS**

An overview of findings and recommendations for the site visit follows. *PART II: Pyramid Lake Housing Authority Technical Housing Assessment Report* provides a more detailed discussion and analysis of the findings.
Only two of the 208 homes managed by PLHA were inspected. The findings listed below are specific to those two inspected homes and may not be issues in other homes managed by PLHA. PLHA should reference these findings and make subsequent recommendations, when similar moisture problems are encountered in other homes PLHA manages.

Findings:

**Ambiguity in Defining Thermal Boundary**

The PLHA needs to make a determination as to whether the crawl spaces are within or outside of each unit’s thermal boundary, where the insulation is placed, and take the appropriate steps once this determination is made.

**Bathroom Ventilation**

All the bathroom fans appeared to be originally installed ones and, although they functioned adequately when on, the controls and noise discouraged use by the residents. All the bathroom exhaust fans vented to the outside, as did the kitchen exhaust fans.

**Dryer Venting**

Improper dryer venting can send excessive moisture to the crawl space. Dryer vents should have smooth metal ductwork with a minimum of bends and the minimum needed length.

**Crawl Space ground covers**

Seal crawl space ground covers at their joints and to the foundation walls.

**Furnaces/Ductwork**

Some furnace systems function poorly, if at all, because of improper installation, leaky ductwork, or occupant behavior.

**Ventilation Systems**

Replace existing bathroom fans with low-sone models and controlled by timers so that they continue to operate for at least 20 minutes after use of the bathroom.

**Drainage**

Overall site drainage around the homes is good. Localized holes and depressions contribute to interior crawl space moisture problems. Particular care should be taken between walkways and homes.
Window Sealing

Condensation between the storm and primary windows was the result of improper sealing.

Maintenance

It is important that residents notify PLHA immediately regarding moisture and mold problems and that these concerns be promptly investigated. A simple untreated leak can quickly turn into a complicated, expensive mold problem.

MOLD TESTING

The assessment team’s general message is: if mold is inside a building, it should be cleaned up. Generally, it is not necessary to identify the species of mold growing in a residence. There is no baseline of acceptable or unacceptable mold concentrations in a home. This message is consistent with other federal agencies and experts as documented below.

The Bemidji Area Indian Health Service Office of Environmental Health and Engineering, Environmental Health Services Section (BAIHS EHSS), *Guidelines on Assessment and Remediation of Fungi in Indoor Environments* position on testing is:

Consistent with Center for Disease Control (CDC) and Environmental Protection Agency, BAIHS EHSS does not recommend testing as the first response to an indoor air quality concern. Instead, careful detailed visual inspection and recognition of moldy odors should be used to find problems needing correction. Efforts should focus on areas where there are signs of moisture or high humidity or where moisture problems are suspected. The investigation goals should be to locate indoor mold growth to determine how to correct the moisture problem and remove contamination safely and effectively.

The American College of Occupational and Environmental Medicine, states that to successfully remediate mold and moisture conditions, the water and moisture sources must be identified and corrected.

Mold spores are present in all indoor environments and cannot be eliminated from them. Normal building materials and furnishing provide ample nutrition for many species of molds, but they can grow and amplify indoors only when there is an adequate supply of moisture. Where mold grows indoors, there is an inappropriate source of water and moisture that must be identified and corrected before remediation of the mold colonization can succeed. Mold growth in the home, school, or office
environment should not be tolerated because mold physically destroys the building materials on which it grows, mold growth is unsightly and may produce offensive odors and mold is likely to sensitize and produce allergic responses in allergic individuals. Except for persons with severely impaired immune systems, indoor mold is not a source of fungal infections. Current scientific evidence does not support the proposition that human health has been adversely affected by inhaled mycotoxins in home, school, or office environment.

BAIHS EHSS Guidelines on Assessment and Remediation of Fungi in Indoor Environments discusses the limitations of testing.

Mold testing only provides a snapshot estimate for a single point in time and a single location. How well the test represents other locations and times is uncertain since the amounts and types of mold in the environment are always changing. Furthermore, there is no basis for setting a baseline of acceptable or unacceptable mold concentrations. The variability can be especially large for airborne molds, with significant changes occurring over the course of hours or less. Caution must also be used in interpreting surface testing results, since mold growth or deposition may not be uniform over an area and may increase or decrease as time passes. Unless many samples are taken over a period of time and the investigator has been mindful of building operations and activities during the testing, the results might not be very representative of typical conditions; in addition, tests reflecting typical conditions may also miss evidence of problems that only occur infrequently (water leaks during rain storms).

Mold testing is often expensive. If testing is unnecessary or done poorly, the money will not be available for remediation and repairs. The following web sites and references provide further information on mold remediation and testing.

**Indoor Air Quality**

**Ball State University Indoor Environment Notebook** - General resource on a number of topics related to indoor air quality.

http://publish.bsu.edu/ien/archives/archive_list.htm (will open a new browser window)

**Mold**

**EPA** - Mold Remediation in Schools and Commercial Buildings

http://www.epa.gov/iaq/molds/index.html (will open a new browser window)

**New York City Department of Health Bureau of Environmental & Occupational Disease Epidemiology** - Guidelines on Assessment and Remediation of Fungi in Indoor Environments

http://www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.html (will open a new browser window)
References

*Guidelines on Assessment and Remediation of Fungi in Indoor Environments.* Bemidji Area Indian Health Service Office of Environmental Health and Engineering, Environmental Health Services Section


FUTURE HOUSING AUTHORITY ACTIONS

PLHA was very organized and helpful to the assessment team. The staff and residents were friendly and eager to resolve the mold situation. PLHS maintains a close partnership with the residents.

PLHA should gear future actions toward strengthening the partnership between PLHA and residents, educating occupants on minor maintenance and equipment use issues, and addressing appropriate installation and construction techniques with maintenance staff. Due to the dry climate mold is not expected to be a major concern of the Housing Authority. Nevertheless, problems relating to plumbing or resident use (such as disconnected dryers, not using bathroom ventilation) may bring moisture into inappropriate areas and cause problems. Therefore communication between PLHA staff and residents is essential.

Giving occupants the skills and knowledge to maintain, utilize, and repair the home will improve the relationship between PLHA and residents as well as improve indoor moisture conditions. Prompt attention to water and/or moisture issues resulting from maintenance incidences is important – it is not enough just to repair the leak – maintenance staff should also ensure that saturated parts of the building have dried.

It should be noted that the assessment team also examined new construction and did not note any problems with current construction practices.

PROGRAMMATIC RECOMMENDATIONS

A particular challenge to all housing authorities is the development of a prompt and effective service delivery system to address mold and moisture conditions. This requires a partnership between the housing authority and residents with a system that includes training for the maintenance staff on how to implement the technical recommendations and training for residents on their roles and responsibilities as homeowners and tenants.
PLHA has already taken action steps to create a partnership. Additional steps to supplement their program could include formalized methods for addressing mold problems and maintenance issues as they occur. For example:

1. Mandatory attendance at annual homeowner/tenant clinics as part of the annual recertification process. At these clinics, provide instruction on home maintenance issues, such as identifying and repairing leaks, checking for disconnected dryer vents, etc.

2. During the annual recertification process, ask occupants to complete a survey based on Housing Quality Standards (HQS) with additional questions on mold and moisture conditions in their homes. Completing the survey further engages residents in their own home maintenance. Furthermore, the survey responses provide additional information to the housing authority on unreported problems, especially leaks and inoperable fans that might contribute to an unsafe, unhealthy home environment.

A supplemental program could be implemented for maintenance staff. Mandatory meetings will educate personnel on regular maintenance issues, appropriate installation methods, and suitable construction practices to reduce moisture and prevent mold and mildew.
Executive Summary

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EXECUTIVE SUMMARY

Two existing homes were inspected for mold and moisture problems for the Pyramid Lake Housing Authority (PLHA) located in the Pyramid Lake Paiute Indian Reservation. In addition, homes under construction were inspected in order to ascertain if current construction practices were in accordance with healthy homes practice. Paul Knight and Eugene Goldfarb of Magna Systems and Elton Jones of the U.S. Department of Housing & Urban Development conducted the investigation on February 8 - 9, 2005 accompanied by Ms. Jackie Mix of PLHA.

Exterior and interior inspections were conducted. The inspection process involved visual assessment of both interior and exterior conditions, airflow measurement of bathroom exhaust fans and resident interviews.

The relatively minor complaints included:

- mold in bathrooms
- window condensation
- wet crawl space
- poor ventilation

Minor mold was found in both inspected homes and both situations can easily be corrected. The Cactus Circle home has mold in the upstairs bathroom, which can be solved with the proper fan control. The Railroad Circle home not only needs work to remove mold in the crawl space by the bandjoist, but also needs a re-evaluation of the location of the thermal boundary.

Only two of the 208 homes managed by PLHA were inspected. The findings listed below are specific to the homes inspected and may not be issues in other homes managed by PLHA. PLHA should reference these findings and make subsequent recommendations when similar moisture problems are encountered in other homes.

Principal Findings:

1. The PLHA needs to make a determination as to whether the crawl spaces are within or outside of each unit’s thermal boundary and take the appropriate steps once this determination is made.

2. All the bathroom fans appeared to be the originally installed ones and although they functioned adequately when on, the controls and noise discouraged their use. All the bathroom exhaust fans vented to the outside, as did the kitchen exhaust fans.

3. Improper dryer venting can send excessive moisture to the crawl space. Dryer vents should have smooth metal ductwork with a minimum of bends and the minimum length.
4. Seal crawl space ground covers at their joints and to the foundation walls.

5. Some furnace systems functioned poorly, if at all, because of improper installation, leaky ductwork, or occupant behavior.

5. Replace existing bathroom fans with low-sone models and controlled by timers so they operate for at least 20 minutes after use of the bathroom.

6. Overall site drainage around the homes is good. Localized holes and depressions may be contributing to interior crawl space moisture problems. Particular care should be taken between walkways and homes.

7. Condensation between the storm and primary windows was the result of improper sealing.

8. It is important that residents notify PLHA immediately regarding moisture and mold problems and that these concerns be promptly investigated. An easily fixed untreated leak can quickly turn into a complicated, expensive mold problem.

The report provides technical recommendations and discussions focusing on these items. Appendix A includes a summary of findings at each inspected unit. Appendix B provides observations and recommendations for each unit.
INTRODUCTION

The Building Research Council and Magna Systems Inc. responded to a request from the Eastern/Woodlands Office of Native American Programs to assess site and structural conditions contributing to mold and moisture problems in homes managed by the Pyramid Lake Housing Authority (PLHA) just northeast of Reno, Nevada, and to inspect new homes under construction. Paul Knight and Eugene Goldfarb of Magna Systems Inc. and Elton Jones of the U.S. Department of Housing & Urban Development conducted the investigation on February 8 – 9, 2005. Inspected units were pre-selected by PLHA.

PLHA reported the following moisture problems in their homes:

- mold in bathrooms
- window condensation

Mold was found in both inspected homes. One home (736 Railroad Circle) had moderate mold problems in the crawl space where a water line had leaked. The problem appeared to have been serious at one time but was waning now that the leak had been fixed, although other problems were noted in the home. The other home (119 Cactus Circle) had a mild problem in a bathroom where a window had been installed and, as a result, the ventilation fan was probably not being used as often. Disconnected dryer vents were found in the crawl spaces of each home. The overall conclusions of the visit include:

- There were no serious endemic problems in PLHA homes.
- Only minor modifications are suggested for the new construction.
- PLHA look into improving its response to water related maintenance problems.

The principal issue highlighted by this study is the failure to clearly define the thermal boundary for the units. The thermal boundary of a home seems like a simple thing to identify; it's the building sections (wall, ceiling, floor) that separate the exterior climate from the interior conditioned climate. Once a thermal boundary is defined, adequate air sealing and insulation must be provided along that boundary. The PLHA needs to determine if the crawl space is within or outside of the thermal barrier.

Although the units were not overly wet the bathroom mold indicated the need to promote the use of ventilation fans – low-sone (quieter) fans controlled by timers instead of manual switches are recommended.

Reliance upon secondary (wood stoves) heat sources may be indicative of poorly functioning furnace systems. The supply runs were constructed with too much ductwork and had too many bends; and the supply air grilles were obstructed by furniture and other household items.
All the homes had fairly good site drainage. One architectural detail, sidewalks placed immediately adjacent to the crawl space walls, could be responsible for deteriorated siding and drainage into the crawl space.

Propane was the primary source of heat in two inspected homes. One home utilized an interior wood stove as its primary heating source.

SECTION 1 – METHODOLOGY

Visual inspection and various airflow measurements were used to assess mold and moisture conditions in the homes.

The results of the mold and moisture assessments were compiled on a spreadsheet, with broad categories of common moisture problems noted. This data is presented in Appendix A of this report. Findings and recommendations for individually inspected homes are presented in Appendix B.

Visual Inspection

Housing inspections consisted of visual assessment of mold and moisture conditions. The assessment forms were organized for a room-by-room inspection. All rooms were examined for water damage and evidence of mold. Assessment of kitchens, bathrooms, utility rooms, crawl spaces and attics included additional inspection relating to plumbing, localized ventilation, water entry and other moisture source issues.

The exterior of the homes were inspected for rainwater and snow melt management, including site grading, roof condition and gutter system.

Residents were interviewed to gather history on moisture problems, plumbing leaks, site drainage issues, winter condensation, health issues, number of occupants and other useful information that could be offered.

Digital photographs were taken at each home to visually record notable conditions.

Measurements

Actual ventilation rates of bathroom fans were measured with an exhaust fan flow meter. The flow meter consists of a gasketed pan that is placed tightly over an operating exhaust fan (Figure 1). The pan has a variable orifice and a connection for a digital manometer. The manometer measures the pressure difference between the pan and the

Figure 1 - Exhaust fan flow hood and digital manometer
house during fan operation. Based on the setting of the variable orifice and the measured pressure difference at the fan, the cubic feet of air per minute (CFM) exhaust by the fan is calculated.

SECTION 2 – PYRAMID LAKE HOUSING DESCRIPTIONS

PLHA manages around 208 homes on the reservation of which 52 are Low-Rent with the remaining 156 homes being Mutual Help. Two homes were inspected. Inspected homes were stick built around 1980. One was a one-story ranch the other was a two-story home – both homes had crawl spaces.

All the inspected homes were 2” x 6” construction. Sidewall insulation was inspected and assumed to be R19 fiberglass batts. Attics were not accessible except for in one new home. The attic was insulated with blown fiberglass. The attic had no signs of mold or moisture problems. Central return air ducts were located in the attics. Soffit and ridge vents were the common attic ventilation strategy.

Crawl space foundation walls were poured concrete. Foundation walls were insulated on the inside with fiberglass batts. Floors above the crawl spaces were also insulated with fiberglass batts (Figure 2). The foundation walls included vents. Ground covers were not continuous, nor were they sealed. Supply air ductwork and plumbing lines were also located in crawl spaces.

SECTION 3 – FINDINGS

3.1 Ambiguity in Defining Thermal Barrier

The principal issue highlighted by this study was the failure to clearly define the thermal boundary for the units. The location of the thermal boundary in the PLHA homes was not clear. Both the foundation walls and floor above the crawl space were insulated. Only one of the building sections needed insulated. Save construction dollars by determining where the thermal boundary actually is (foundation walls or floor above the crawl space) and insulating only that building section.

The thermal boundary of a home is a simple thing to identify; it is where the insulation is located (Figure 3). It is the building sections (wall, ceiling, and floor) that separate the exterior climate from the
interior conditioned climate. Once a thermal boundary has been defined, adequate air sealing and insulation must be provided along that boundary. The PLHA must determine if the crawl space is to be within or outside of the thermal boundary.

For example, it was mentioned that the floor above the crawl space was insulated because occupants have complained of cold floors. This makes sense since the crawl space vents were open during the winter. If the crawl space was cold, the foundation insulation was ineffective. On the other hand, if the crawl space vents were sealed and insulated, the crawl space was likely to remain relatively warm, eliminating the need for floor insulation. See Section 4.2, “Crawl Spaces”, for additional information.

### 3.2 Bathroom & Kitchen Exhaust Fans; Clothes Dryers

Properly operating and vented exhaust fans and clothes dryers remove moisture from bathrooms and homes. Bathroom exhaust fans were found in all the homes and were vented to the outside (assumed through metal ribbed ductwork). An exhaust fan flow meter was used to measure actual CFM exhausted by the bathroom fans. The measured exhaust ranged between 36 CFM and 45 CFM, which was adequate but not good. The rated CFM was 100 CFM. All bathroom fans vent to the outside. An “on/off” switch that also controlled the bathroom light controlled bathroom exhaust fans. All the bathroom fans were quite noisy. Occupants tend not to use fans that are loud.

At a minimum, bathroom exhaust fans should provide a minimum ventilation rate of 70 CFM. None of the bathroom exhaust fans were vented near this rate. It is not unique to the housing stock at PLHA to have bathroom fans measuring below their rated exhaust capacity. This is commonly seen in all housing types, regardless of economic strata.

All the kitchen fans vented to the outside. Venting kitchen exhaust fans to the outside is imperative to controlling moisture levels while cooking.

Clothes dryers were designed to vent to the outside through the crawl spaces, but dryer vents were disconnected in both existing homes and both dryers were venting directly into the crawl spaces (Figures 4 & 5).

### 3.3 Crawl Spaces

Although the Tribal housing was not subject to endemic influences, such as a high water table, moisture can still enter the crawl space and when it does, can cause mold. At 736 Railroad Circle a water pipe connecting to an outside faucet was allowed to leak for approximately four months and the crawl space, although relatively dry at the time of
inspection, contained extensive root growth indicating the presence of a great deal of water at one time (Figure 6). Also, the insulation on the exterior walls hindered evaporation and the rim joists were still saturated and moldy 1 to 2 months after the leak had been fixed (Figure 7).

Some of the moisture may have entered the crawl space because of the lack of positive drainage between the sidewalk and the home (See discussion on site drainage below).

Other common problems in both crawl spaces included improper dryer venting (both dryers vents were disconnected) and failure to seal the ground cover (Figure 7).

### 3.4 Furnaces/Ductwork

There was some question as to whether the furnace systems are operating optimally. At 736 Railroad Circle the occupant complained the furnace was not effective and she primarily relied upon her auxiliary wood stove. In both homes excessive runs of flex duct with excessive bends made it difficult for the system to drive an adequate flow of air (Figure 8). Supply air registers were blocked by furniture and clutter (Figure 9). Supply air ducts located in the crawl space were torn (Figure 10). In the Railroad circle home, this failure to run the furnace (and relying upon the wood stove) resulted in mild mold along the exterior walls (Figure 11). In a properly operating system the supply vents were located along the exterior wall so that they washed the wall with warm air. If this did not occur then mold could result.
3.5 Bathroom Ventilation

Both homes had bathroom exhaust fans with adequate capacity but sub par controls. The bathroom fans were measured at 36 and 45 CFM and simple on/off switches controlled the bathroom lights and the fans. The fans were very noisy. Thus occupants would only keep the fans on when the lights were on.

This simple fact (that occupants do not like to run noisy fans) was illustrated by the mystery of why the installation of a new window at 119 Cactus Circle should cause a mold problem. Prior to the installation of the window, the bathroom (Figure 12) was dark and the homeowner had to use the bathroom fan (when the light was on). Once the window was installed the homeowner had the option of running or not running the fan, since natural daylight illuminated the room. He chose not to run it, so moisture accumulated and caused mild mold (Figure 13).

The combustion air supply to the furnace was also somewhat clogged (Figure 14).

3.6 Site Drainage

Site drainage was generally good around all the inspected homes. None of the inspected homes had gutter systems. Gutters were not used on any PLHA homes, even over entryways (although storm water was diverted). Lack of gutter systems did not appear to be a cause of moisture problems in the homes. The Railroad Circle Home crawl space problem could have been exacerbated by the low spot for the water to pond near the front window (Figure 15). The sidewalk on the newer homes was placed along the foundation walls. It was important that these walkways be sloped away from the building (Figure 16).
The older homes had an exterior horizontal bandjoist around the perimeter of the home. The siding sat on the edge such that water could not readily drain from it (Figure 17). This detail had resulted in siding deterioration. This detail was not used on the newer homes.

3.7 Window Sealing

Condensation was noted in the front bedroom window in the Railroad Circle home, apparently because the seal on the storm window was more secure than the seal on the primary window. Moist air from the home entered the space between the windows and condensed on the surface of the storm window (Figure 18).

3.8 Occupant Lifestyles

Occupant lifestyles also contributed to moisture and other indoor air quality issues, which include:

- Furniture and clothing covered supply ducts.
- Slowly reported and repaired plumbing leaks.
- Overstuffed closets.

Educate occupants in the following items to assist in solving and eliminating moisture and mold problems in their homes. A number of occupant related items found during the site visits include:

- Dirty or missing furnace filters
-Disconnected dryer vents
- Closet clutter
- Clogged fresh air intakes
- Blocked supply grilles

It was noted in the Railroad Circle home that supply grilles were blocked by furniture and clothes and the occupant reported using the forced air system only in the early morning and relying upon the wood stove for the remainder of the day. This, unfortunately, eliminated airflow across the exterior walls and windows which elevated

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the glass surface temperature (raising the dew point temperature\(^1\)) and helped wash away moisture that may have condensed on the glass surface or the wall.

A major problem was the failure to address potential problems in a timely manner. Although the Railroad Circle home had the water line leak fixed, it had a current problem with a leaking kitchen sink that either had not been reported or repaired (Figure 19). PLHA should educate residents to be alert to potential moisture problems and the need to report them promptly.

SECTION 4 – TECHNICAL RECOMMENDATIONS

The following recommendations are based on the site visit findings.

4.1 Bathroom & Kitchen Exhaust Fans; Clothes Dryers

Bathrooms, kitchens, and laundry rooms generate large amounts of moisture. Properly operating exhaust fans are necessary to remove moisture from these spaces. Maintenance of bathroom fans and replacement of broken fans are high on this priority list:

- Replace bathroom exhaust fans when fans are inoperable, when bathroom rehabilitation is planned, or when mold is found in bathrooms. Rate fans for a minimum 70 CFM at 0.25” of static pressure (the rating provided on the box is generally at 0.10” of static pressure).

- New bathroom fans should have sone ratings no higher than 1.5. Sone is a rating for sound – the lower the sone rating, the quieter the fan. Occupants tend not to use loud fans because of the noise. Low-sone fans include Broan Solitaire and Panasonic WhisperCeiling and WhisperLite series. Low-sone fans generally cost between $75 and $100.

- Replace flexible ribbed exhaust vents with smooth metal exhaust vents. The team recommends the use of round, smooth sheet metal ductwork (Figure 20). Minimize duct length, turns and bends in the ductwork; a two to three foot run

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\(^{1}\) Dew point temperature is the warmest temperature of a surface where water condensation from the surrounding air would form on that surface. If the surface temperature is increased, the dew point temperature also increases which decreases the potential for condensation to occur.
should be before the first elbow and all elbows should have a long radius (Figure 21). Smooth duct provides less resistance and improved flow over ribbed ductwork. Recommend to occupants that bathroom fan grilles be cleaned of dust and lint as needed.

- Replace fan on/off switches with 60-minute timer switches (Figure 22). Recommend to occupants that fans operate for at least 15 minutes following showering or bathing. Timer switches cost between $15 and $50.

- Replace any existing combination bathroom light/fan switches with fan delay timers. A fan delay timer is a two-function switch that is typically wired to a fan and a light (Figure 23). When the switch is turned-on, both the light and exhaust fan are turned-on. When the switch is turned-off, the light was off, but the fan operated for an extended period of time, from 1 to 60 minutes. Fan delay timers are about $35.

- Periodically inspect all bathroom and kitchen exhaust fan ducts. Ensure that exhaust ducts are vented outside, properly attached and sealed to the exhaust fan housing and to roof or wall vent caps.

- Periodically inspect dryer vents. Correct the following conditions when found:
  - Install dryer vent when missing or damaged.
  - Replace crimped or cracked dryer vents.
  - Reconnect disconnected dryer vents.
  - Replace plastic ribbed dryer vents with smooth metal vents as space permits.

4.2 Crawl Spaces

PLHA must make a decision on whether the crawl spaces are they to be inside or outside of the thermal envelope.

If the foundation walls form the thermal boundary, then the following items should be done:
1. Insulate foundation walls to an R-value\(^2\) between 5 and 10.

2. Ground covers should be continuous. Joints between pieces should be overlapped and sealed with sheathing tape. Openings around footing and piers should also be sealed. The edges should be sealed to the foundation wall (Figures 24 & 25).

3. Seal crawl space vents (or at least close during the winter). Leaving vents open in an insulated wall is similar to leaving a window open during the winter. The foundation insulation has no effectiveness.

4. Heating ducts could remain in the crawl space. However, since the crawl space was conditioned space, do not insulate the ducts and all duct joints should be sealed to improve airflow and comfort in the home.

5. Furnaces currently draw combustion air from the crawl space. Dedicated ductwork needs to bring combustion air to the furnaces from either outside the home through the crawl space and/or from the attic. Crawl space vents should not be sealed unless provisions are made to bring combustion air to the furnaces.

If the floors above the crawl spaces are to form the thermal boundary, then the following items are necessary:

1. Floor should be insulated with R19 insulation. Insulation should completely fill cavity. Batts should not be compressed at floor joists (Figure 26).

2. All holes and penetrations through the floor should be sealed before the floor is insulated. Typical homes would include those around drains, plumbing lines and electrical penetrations.

3. Since the heating ducts are outside the thermal boundary, seal all joints well. Insulate all heating ducts.

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\(^2\) R-value means resistance to heat flow. The higher the R-value, the better the insulating quality of the material. Insulation is rated by its R-value.
4. Insulate all plumbing lines to prevent pipes from freezing.

5. Install a ground cover and seal as described above.

6. Leave the crawl space vents as they currently are to provide combustion air to the furnaces.

4.3 Ductwork

The following recommendations were made to improve airflow in the bedrooms:

1. Check the ductwork to eliminate excessive runs and bends. If possible, replace flex ducts with smooth metal ductwork.

2. Remove obstructions such as furniture or clothes from supply vents.

3. Check bedroom pressure differences with respect to the hallway. Pressure difference should be no greater than 2.0 Pa between the bedroom and hallway with the air handler operating. Pressure relief is needed if a pressure of 2.0 Pa is exceeded. Pressure relief can include undercutting doors, installing transfer grilles or, in extreme cases, installing a return air duct to the bedroom. Pressure differences can be measured with a manometer.

4. Measure supply air CFM at bedroom registers with a velometer. Flows generally range between 70 CFM and 100 CFM, depending on bedroom size. Damper system to increase airflow to bedrooms as necessary.

4.4 Window Sealing

Check seals around prime windows when condensation occurs on the storm windows. Caulk around prime window, as necessary. Inspect exterior storm window to assure that weep holes are not sealed or blocked with dirt.

4.5 Site Drainage

Site drainage was generally good at the inspected homes. Positive drainage is of the utmost importance. Ensure that storm water does not drain into crawl space. For the Railway Circle Home this meant filling in the area between the walkway and the foundation wall. In general, grade directly at the foundation to ensure a soil pitch away from the homes by at least 5% (6 inches per 10 feet).

4.6 Occupant Education

Occupant cooperation is essential to minimize moisture and other Indoor Air Quality problems. The many steps to do this include:
1. Instruct occupants on the importance of using bathroom and kitchen exhaust fans during and after bathing and cooking activities to remove moisture from these spaces. As inoperable fans are replaced, provide similar instructions.

2. Inform occupants not to use crawl spaces for storage.

3. Change furnace filters on a monthly basis during the winter.

4. Promptly report plumbing leaks. Recognize the difference between plumbing leaks and sweaty pipes and fixtures. Wipe-up moisture from sweating pipes and fixtures.

5. Inform occupants to avoid blocking supply air vents with furniture or clutter.

6. Show occupants combustion air intakes for their furnaces. Inform them of the importance of keeping these intakes open. Blocking these intakes may cause a furnace backdrafting problem (combustion gases spilling into the home rather than venting to the outside). Backdrafting appliances can cause serious health problems.

SECTION 5 – DISCUSSION OF COMMON PROBLEMS

5.1 Crawl Space Design and Ambiguity in Defining Thermal Barrier

The thermal boundary is the building section that separates conditioned space from outside conditions (Figure 27). A clear distinction should be made whether the crawl space walls or the floor above the crawl space is the thermal boundary for a home. Insulation on the foundation walls indicates that the foundation walls form the thermal boundary. Crawl space vents indicate that the floor above the crawl space is the thermal boundary. Once a thermal barrier is defined adequate air sealing and insulation along that barrier must be provided. The PLHA needs to decide if the crawl space is within or outside of the thermal barrier.

Both the above conditions were found in the inspected homes. Crawl space walls were insulated with batt insulation, indicating that the (crawl space) foundation walls form the thermal boundary. However, all of these crawl spaces were vented, and the floors (above the crawl space) were insulated, as were the ducts – steps usually taken only if the crawl space is outside the thermal barrier. If the
crawl spaces are to be vented, then the floors above the crawl spaces should be insulated and air sealed with all mechanics (ductwork, plumbing) above the insulation, or else carefully insulated if left in the crawl space (the plumbing was not insulated).

The mechanicals are currently exposed in the crawl spaces. Depending upon where the thermal boundary is located, one of two strategies may be employed. It is our recommendation that the crawl space foundation walls become the thermal boundary given the current conditions found in the homes, but only if provisions are made to provide combustion air to the furnaces from outside the crawl space (See section 4.2, Crawl Spaces’).

**Crawl Space Walls is the Thermal Boundary**

The crawl space is unvented (Figure 28). This figure shows an exterior insulation system that allows a shallower frost wall, although the foundation wall may be insulated down to the footing, either on the inside or outside of the foundation wall. The drawing also shows a concrete pad sloped to a sump pump. Should water get into the crawl space, it can be drained and pumped from the crawl space. The concrete pad serves as a ground cover that can be cleaned and is more durable than a polyethylene ground cover.

![Figure 28: Unvented crawl space](image)

In essence, the crawl space is designed as a stubby basement that is conditioned as a result of ductwork being located there. The ductwork had open supply and return
registers in some cases. As unvented crawl spaces are not yet allowed by most codes, it may be necessary to add closeable vents to obtain a building permit.

Floor Above the Crawl Space is the Thermal Boundary

A detail showing a well-vented crawl space is shown in Figure 29. The "bellyboard" membrane seals the home from the crawl space. A small drain to discharge any leaks or overflows from the bathroom and kitchen may be added. Do not run ductwork or piping in the crawl space, except for services. Insulate water service piping with electric heating tape. Generous venting is required in the foundation walls, with the vents held well off the ground. Vents installed according to code can only deal with small amounts of moisture. Consequently, it is essential to include a continuous and sealed ground cover to ensure that water drains away from the crawl space.

![Figure 29 - Vented Crawl Space](image)

The following points relate to crawl spaces in general, regardless of thermal boundary:

1. Crawl spaces should have easy access and good lighting so as to enable regular inspections.

2. Seal return air grilles, if present in crawl spaces.

3. Water in crawl spaces typically comes from poor rainwater management outdoors, plumbing leaks, air conditioner condensate, or water softener discharge.
4. Cover the ground surface with a ground material: a concrete slab, a polyethylene sheet or other vapor-proof material. The ground cover must be sealed to the foundation walls. All joints and seams must also be sealed. Seal the ground cover to the foundation piers interior to the crawl space.

**Ground Moisture Barrier**

Crawl space moisture can lead to condensation, mold, and rot. Air passing through the soil can contain radon and pesticides. Covering the ground with an airtight moisture barrier establishes an air barrier and seals out moisture and soil gases.

Ground moisture barriers should be a minimum 6 mil polyethylene plastic. Complete or partial coverage of ground moisture barriers will depend on the accessibility and working conditions in the space. If the entire crawl space floor is not accessible, cover as much as possible.

1. Cover the ground completely with a moisture barrier without voids or gaps.

2. Extend ground moisture barrier up the foundation wall for a minimum of 6 inches. Seal ground moisture barrier to foundation wall with acoustical sealant or other effective adhesive. Secure with furring strips.

3. Overlap ground moisture barrier seams at least 12 inches and seal seams with acoustical sealant, such as 3M #8086 builders’ tape or equivalent.

4. Seal the ground moisture barrier to concrete footings with acoustical sealant or other effective adhesive.

5. Use duct mastic to seal the ground moisture barrier to the foundation wall and to seal joints between sheets. Apply duct tape to temporarily hold the ground moisture barrier in place. Embed the duct tape in duct mastic extending the mastic a minimum of 3 inches beyond the edge of the duct tape.

5.2 **Furnaces/Ductwork**

There was some question as to whether the furnace systems were operating optimally. At 736 Railroad Circle the occupant complained that the furnace was not effective and stated she primarily relied upon her auxiliary wood stove. In both homes excessive runs of flex duct (particularly at Railroad Circle) with excessive bends made it difficult for the system to deliver an adequate flow of air. Supply air registers were blocked by furniture and clutter. The ducts located in the crawl space were torn. In the Railroad Circle home, this failure to run the furnace (and relying upon the wood stove) resulted in mild mold along the exterior walls. In a properly operating system the supply vents are located along the exterior wall so that they may wash the wall with warm air. If this does not occur then mold may result.
5.2.1 Air Flows

An improperly balanced air-handling system can cause comfort, building durability, and indoor air quality problems. Inspect ducts thoroughly as described below. Make pressure measurements to ensure that the system is balanced.

Duct Improvements to Increase Airflow and Improve Comfort

Consider the following improvements in response to occupant complaints, conditions observed during a thorough duct inspection, and measurements such as airflows from rooms:

1. Ensure that the fan control is adjusted to the optimum fan on/off temperatures and functioning so that the furnace fan is cycling at the desired temperatures.
2. Remove obstructions to registers and ducts such as rugs, furniture, and objects placed in ducts, like children's toys and water pans for humidification.
3. Remove kinks from flex duct, shorten longer than necessary flex duct sections and replace collapsed flex duct with smooth metal duct.
4. Extend supply and return ducts as needed to provide heated air throughout the home, especially into additions to the home.
5. Install registers and grilles where missing. Do not install return air grilles in crawl spaces.
6. Seal significant supply leaks in the crawl space that may be diverting excess distribution air away from the main living spaces of the home.
7. Undercut bedroom doors. Install a transfer grille between the bedroom and main body of home may to improve airflow.

Pressure Measurements

Correct pressure differences greater than +2.0 Pa or more negative than -2.0 Pa. Conduct the test in the following manner:

1. Set-up home for winter conditions. Close all windows and exterior doors. Turn off all exhaust fans.
2. Close all interior doors, including door to furnace closet.
3. Turn on air handler.
4. Place hose from "input" tap on the manometer under the door. Leave "reference" tap open to main body of home.

5. Read measurement for each room (Figure 30).

If pressure difference is more than + or -2.0 Pa with the air handler operating, pressure relief is necessary. To estimate the amount of pressure relief, slowly open door until pressure difference drops between +2.0 Pa and -2.0 Pa. Estimate area of open door. This is the area required to provide pressure relief.

Pressure relief may include:

1. Undercutting the doors
2. Installing transfer grilles (Figure 31)
3. Retrofitting jumper duct consisting of one register in the bedroom ceiling and one register in the hall ceiling with a duct in between located in the attic.

5.3 Bathroom & Kitchen Exhaust Fans; Clothes Dryers

Bathrooms, kitchens and laundry rooms are used for showering, bathing, cooking, cleaning, and drying of clothes. By removing moisture at the source in these areas, exhaust ventilation serves as a source control strategy. Exhaust ventilation dilutes the moisture and places the room in a negative pressure, thus limiting the spread of moisture to the rest of the home until most of the moisture has been removed to the outside.

Bathroom exhaust fans, kitchen exhaust fans and clothes dryers should always vent to the outside rather than into the living space. Venting to the crawl space and attic can lead to moisture problems occurring in these areas. For this reason, localized exhaust ventilation requires ductwork.

The effectiveness of exhaust fans is based on the power of the exhaust fan, length and type of exhaust duct and cleanliness of the fan grille. When there is excessive resistance in the ductwork, the exhaust fan motor may not be powerful enough to vent sufficient
airflow through the duct. The longer the duct length, a smooth duct, and multiple turns and bends in the ductwork create greater static pressure in the duct and less airflow through the duct. For all types of exhaust ventilation, using round, smooth sheet metal ductwork is recommended. A dirty intake grille will also greatly increase resistance and reduce airflow.

Fan capacity is typically listed at 0.10” and 0.25” of static pressure. Bathroom exhaust fans should provide a minimum ventilation rate of 70 CFM at 0.25” of static pressure. Selecting a fan capacity at 0.10” static pressure is appropriate only if the exhaust duct is smooth, straight (no more than one elbow) and less than 15’ in length. For example, a bathroom fan with an exhaust ventilation rate of 90 CFM or 100 CFM (at 0.10”) may have to be selected to obtain 70 CFM at 0.25” of static pressure if there are numerous elbows, the exhaust duct is ribbed and the length is over 15’. Fan performance curves should be reviewed to determine ventilation rates at 0.25”.

Replace non-operable kitchen exhaust fans and kitchen recirculating fans whenever possible with fans venting to the outside. The fans should have a minimum exhaust capacity of 150 CFM. Under no circumstances should recirculating fans be installed in place of the kitchen exhaust fans.

Dryer vents should have smooth-surfaced rigid ducts. Use non-combustible flexible metal duct approved for dryer venting. Duct joints should be in the direction of airflow. Do not fasten ducts with screws or fasteners that extend into the duct. Minimize the length of the duct run, especially with flexible metal duct. Install flexible metal duct without dips or sags. Insulate dryer vents extending through attics.

Minimum duct diameter should be 4” and length should not exceed 25’ from the dryer outlet to the termination point. If duct length is greater than 25’, 5” diameter duct should be used.

Dryer vent caps should have a backdraft damper that closes when the dryer is not being used. Insect screens or small wire cages should not be installed over the vent cap.

5.4 Site Drainage

Design and build the roof so the rainwater lands on the roof, moves to the edge, falls on a soil surface, and some of it will percolate downward through the soil—more in sandy soils and less in clayey soils. The rest will move along the soil surface following the slope, out to the downhill edge of the site. This method is the best way to prevent mold and moisture problems in homes. Homes that allow water to accumulate in the soil that is in contact with the foundation have problems. Keeping the foundation dry is the key to a good indoor environment in most homes. To keep the foundation dry, keep the soil dry that is next to the foundation.

Keeping the soil that touches the foundation dry includes a few general rules and specific guidelines:
1. Rule one is concentration - damage is worse where greater quantities of water are concentrated. A valley on a roof acts like a funnel, with the greatest concentration of water at the base of the valley. Gutters act like funnels that collect water from the edge of the roof and concentrate it in the downspout. On the land, valleys and swales act like collectors or funnels that concentrate the water on the site. If the water management design makes use of funnels (such as valleys, gutters or swales) then they require maintenance to make sure they work as they are intended. Damage is worst where a valley, gutter or swale is blocked.

2. Rule two is the “ground-roof” rule - treat the soil surface as if it were a low-slope roof surface. Pitch the surface away from the home - the steeper the pitch, the better the drainage. If all the water should move to the low edge of the site, plan how to move it there. Avoid areas near the building that can act as water collectors.

Specific site drainage guidelines include:

1. Build the home on a hill, not in a hole. If there is a sufficient amount of exposed foundation, site grading at the home can be improved. If the home hugs the ground, improvements at the foundation are more difficult. A minimum of eight inches of exposed foundation should show between the ground and the beginning of the exterior finish.

2. Identify localized dips and holes immediately adjacent to the foundation and fill with dirt. Tamp the fill material to prevent future settling. Provide sufficient fill material such that drainage occurs away from the foundation.

3. If a sidewalk is placed next to the home, ensure the sidewalk slopes away from the home.

4. If the home has no gutters or the gutters are ineffective, then the base of the soil around the home has to serve as a gutter itself. The surface should prevent splash back onto the exterior finish of the home. Design the soil with a pitch that effectively moves water away from the home. Avoid situations where a walk traps water next to the home and correct (fill in the area) when it occurs. Install a localized gutter to keep water from pooling in these areas.

5. Good tamping or compaction of the backfill is very helpful because it keeps water up on the surface where it can be managed by slope. Soil at the outside corners of the foundation, where the downspouts are usually found, can always be tamped because the corner will never collapse inward.

6. Bushes and other plantings are helpful, if their root balls soak up a lot of water. Also they can be planted strategically near downspouts so that downspout extenders are less likely to be kicked off or removed during lawn mowing.
Given the lack of precipitation received in this climate, site drainage and gutter systems are not significant items. However, there may be short-term drainage problems if a large amount of rain is received in a short period of time. Some of the planter beds are unintentionally blocked with sidewalks that collect and hold rain water adjacent to the foundation. Installing a gutter and downspout to keep water from collecting in these areas may be helpful. The following information is provided should PLHA consider the installation of gutter systems.

1. Gutters can be an effective rainwater/snow management system. Pitch the gutters to the downspout. Short gutters may be hung level. In hip roof homes, consider using downspouts only on the downhill side not on the uphill side.

2. Secure downspouts to the home. Never undersize gutters, but some oversizing is appropriate. Fasten elbows and straight sections together with pop rivets—screws that project into the downspout can lead to clogging.

3. At the base of the downspout, the water has to be directed away from the foundation of the home, past the backfill onto the undisturbed soil, which may be 3 feet to 5 feet out from the edge of the home. If it is allowed to dump water close to the foundation, into the backfill, it will concentrate the water next to the foundation. The traditional way to discharge the water away from the home involves using downspout extenders (sections of straight downspout) or splash blocks. The soil at the base of the downspout should be sloped away from the home at a minimum of 5% slope, which six inches of fall in the first 10 feet away from the home gives.

5.5 Occupant Items

There are a number of occupant items that can cause moisture and mold problems. Train occupants in the following items to assist in solving and eliminating moisture and mold problems in their homes:

- What is mold and what causes it
- Keeping furniture and other household items off of floor registers
- Use or misuse of exhaust fans
- Use of crawl spaces and not storing items in them
- Changing furnace filters on a monthly basis
- Periodic inspection of dryer vents
- Difference between plumbing leaks and water condensing on pipes
- Storing fire wood outside the home
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<td>Yes</td>
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<td>Propane/FA</td>
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<td>No</td>
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MH = mutual help
LR = Low Rent
Appendix B:

Inspection Number: 1-1
Address: 736 Railroad Circle
Age: approx 25 yrs
House Type: Low Rent
Occupancy: 3
Bedrooms: 2
Foundation: Poured Concrete
Heat Type: FA NG Furnace supplemental wood stove
Construction: Stick-built, 2” x 6”

Mold and Moisture Conditions: A hose bib leak near the front door had flooded the area adjacent to the home (Figure 2 & 3). The leak reported in the summer of 2004 was not corrected until December 2004. Extensive plant root systems were found in the entire northeast quadrant of the crawl space (Figure 4). Even one to two months after the condition had been repaired, there was still a great deal of moisture in the crawl space, especially in the band joist near the leak behind the insulation (Figure 5), but also including other structural members (e.g. floor joists).

The dryer vent was disconnected, with evidence of lint and additional moisture entering the crawl space. The vapor barrier was present, but not sealed (Figure 5). This was not a major problem, since there did not appear to be ground water near the surface.

Mold was also found on the east bedroom window, where condensation was noticed on the storm window (Figure 6). In that case it appeared that the seal around the storm window had more integrity than around the interior window; openings were clearly visible into the space from the interior window.
Appendix B:

**Rainwater Management:**
Site drainage was fairly good, with the exception of the area between the front walk and the home (Figure 7). Not only had water pooled in this area when the hose bib was leaking, but it also appeared that water running off the roof (there are no gutters) would fall from the sidewalk into this area and then into the crawl space. We also noted some deterioration of the siding from rainwater, where the siding met and rested upon the lip of the exterior band joist (Figure 8).

**Crawl space:** As noted above, the crawl space was very moist, although the presence of dry root material indicated that it had been much worse in the past. In addition to residual water from the hose bib leak, the clothes dryer was partially disconnected (Figures 9 and 10), and there was condensation on some of the plumbing waste lines.

**Bathroom/Kitchen:** The bathroom exhaust fan measured 45 CFM (it’s rated at 100 CFM) and was controlled by a separate switch. There was evidence of some mold above the shower surround and on the ceiling wall. The kitchen exhaust fan vented to the outside. A large bucket filled to the top with water sat directly under the kitchen sink (Figure 11). The wood under the sink was deteriorated. The occupant showed us a puncture in the sink.

**Attic:** There was no access to the attic.

**Heating System:** The primary heating system was natural gas forced air but the occupant reported primarily used the auxiliary wood fireplace. Firewood was stored in the home contributing to an increased moisture load. Vents were obstructed throughout the home (Figure 12) and, the ductwork runs in the crawl space were too long, so that the flex duct contained too many bends diminishing the ability of the furnace to deliver an adequate supply of warm air.
to the rooms (Figure 13). A number of holes were in the flex duct itself.

**Occupant Notes:** Three people including two children have lived in the home for four years. There was one smoker.

**Recommendations:**

**Crawl Space**

1. Temporarily remove insulation from bandjoist near hose bib to allow wood to dry.

2. Vent dryer to outside with smooth metal ductwork.

3. Replace damaged ductwork. If possible, use smooth metal duct. Minimize length and number of bends, especially if flex duct is used. Seal all duct joints with duct mastic or high quality foil tape.

4. Consider removing excess insulation at floor joists and ductwork.

**Living Space**

1. Install low-sone bathroom exhaust fan in the bathroom with mechanical timer.

2. Encourage occupant to remove obstructions over all floor registers.

3. Install new sink in kitchen.

4. Replace deteriorated flooring under sink.

5. Repair back door so it has a proper fit and adequate weatherstripping.

6. Ensure dining room window can close (presently obstructed by antenna wire).

**Heating System**

1. Measure actual CFM flow into each bedroom following previous heating system work.

2. Ensure that bedroom door undercuts are sufficient to prevent pressure differentials in excess of 2 Pascals.
### Appendix B:

**Inspection Number:** 1-2  
**Address:** 119 Cactus Circle  
**Age:** approx 25 yrs  
**House Type:** Ranch  
**Occupants:** 2  
**Bedrooms:** 3  
**Foundation:** Poured Concrete  
**Heat Type:** FA furnace (propane)  
**Construction:** Stick-built, 2" x 6"

**Mold and Moisture Conditions:** Mold had been reported in the upstairs bathroom after a new window was installed (Figure 2). Minor surface mold was found on the wall and the ceiling surrounding the tub area (Figure 3). No logical reason was found for why the installation of a window should cause a mold problem. The team thought that perhaps the occupants had previously left on the light and fan which are on the same switch, thus removing the moisture. Once the window was installed, the occupant either turned off or did not even turn on the light and fan. Thus there was no mechanism to remove moisture from the bathroom.

The crawl space was very moist as a result of a disconnected dryer vent (Figure 4).

**Rainwater Management:** There was no gutter system, however the site drainage was good.

**Crawl Space:** The crawl space was insulated on the walls and floor above, as were the heating ducts. The vapor barrier was present, but not sealed. The dryer vented directly to the crawl space resulted in a moist crawl space. Watermarked sand indicated a previous water problem in one corner of the crawl space (Figure 5).

**Bathroom/Kitchen:** The main upstairs bathroom exhaust fan measured 36 CFM and was controlled by a single switch that controlled both the fan and one of the two lights in the bathroom. The fan was rated at 100 CFM.
Appendix B:

There was some moisture under the kitchen sink, but this appeared to be from collecting recycling material in the enclosure.

**Attic:** No access to the attic was available.

**Heating System:** The forced air system was a propane-fired furnace. The ductwork in the crawl space consisted of both insulated smooth metal ducts and insulated flex duct leading to the registers.

**Occupant Notes:** One adult and one child lived in the home. There were no smokers in the household.

**Recommendations:**

3. Install low-sone bathroom exhaust fans in bathroom with fan delay timers.

4. Repair and replace dryer vent so that it vents to outside with smooth metal ductwork.