SAC & FOX HOUSING AUTHORITY TRIP REPORT
Assessment of Mold and Moisture Conditions

Final Report

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PART I

SAC & FOX TRIBE IN THE MISSISSIPPI OF IOWA
MESKWKI HOUSING PROGRAM
TRIP REPORT

INTRODUCTION

Kate Brown from the Building Research Council (BRC) at the University of Illinois Urbana-Champaign, Paul Knight and Eugene Goldfarb from Magna Systems, Inc. conducted a site visit at the Sac & Fox Tribe in the Mississippi in Iowa Settlement. The Tribe administers the housing program through the Meskwaki Housing Program (MHP). The site visit provided technical assistance to the housing program 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: Sac and Fox Tribe of the Mississippi in Iowa: Meskwaki Housing Program Technical Housing Assessment Report: Examining Mold and Moisture Conditions of Homes on the Sac and Fox Settlement.

BACKGROUND INFORMATION

The Meskwaki Nation is located in Tama County in the State of Iowa. The nation is the home of the Sac and Fox in the Mississippi in Iowa. The Indian settlement is centrally located in Iowa. The average annual precipitation is 33.37 inches. Average annual snowfall is 28.2 inches. Average annual maximum temperature is 58.1 °F and the average annual minimum temperature is 38.4° F. Approximately 715 Native Americans reside on the Sac and Fox Settlement. There are about 305 homes under management.

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 Sac and Fox Settlement. Mary Schrader, Meskwaki Housing Director, requested technical assistance to address mold and moisture conditions. The assessment team visited nine Tribal built homes; seven homes built over crawl spaces, one home built with a crawl space and a basement and one home built with a walk-out basement. Eight homes were heated with forced air natural gas and one with forced air propane. The homes ranged in age from newly constructed (2 years old) to approximately 15 years old. Four homes were split-level, three were ranch style, and two were two-stories.

Day 1: Tuesday: February 1, 2005

Tuesday was a travel day. Later in the afternoon the assessment team met with Mary Schrader, Housing Director and Luke Kapayou, Construction Supervisor. At the meeting, the group discussed the next day’s activities, outlined the team’s role while on the settlement, and addressed their issues.
Day 2: Wednesday: February 2, 2005


Day 3: Tuesday, February 3, 2005

In the morning, the assessment team met with Mary Schrader and Wes Hoskey. Wes guided the team through the inspection of two more homes. Later in the morning, the assessment team met with Mary Schrader and staff to discuss findings and strategies for solutions. An hour and a half training session was provided. The assessment team traveled in the afternoon.

FINDINGS

An overview of findings and recommendations from the site visit follows. PART II: Sac and Fox Tribe of the Mississippi in Iowa Technical Assessment Report provides a more detailed discussion and analysis of the findings.

Principal findings from the site inspections for the Meskwaki Housing Program (MHP) include:

1. MHP is successfully solving the moisture and radon problems associated with their crawl spaces. Continue moisture and radon remediation work in homes that have not yet received it.

2. Some ceiling mold issues may be related to high indoor moisture levels as a result of crawl spaces that have not yet been remediated or poor insulation/air sealing over top plates (exterior wall/ceiling juncture).

3. The HRV systems appear to be controlling indoor moisture levels. Two HRV systems were found with minimal or non-existent boost capacity. Check exhaust flows on all HRV systems for sufficient boost capacity.

4. Homes without HRV systems had standard bathroom exhaust fans. Replace the fans as necessary with better quality exhaust fans and controls. Replace the plastic ribbed ductwork used to vent clothes dryers with smooth metal ductwork.

5. Some wall mold and window condensation issues may be related to poor air circulation.

6. Overall site drainage around the homes is good. Fill localized holes and depressions. Replace missing leaders and splash blocks.
7. Occupant lifestyles may also be contributing to moisture and other indoor air quality issues. Lifestyle issues include turned-off HRV systems, clogged fresh air intakes on HRV systems, heavy fabrics hung over windows, blocked supply air registers, and dirty HRV filters.

NEW CONSTRUCTION AND FUTURE HOUSING PROGRAM ACTIONS

In 1999, Tribal Council decided to build all new tribally funded homes based on a health home practice. The health home practice follows the principles adopted by the American Lung Association. The American Lung Association’s mission is to prevent lung disease and promote lung health. Because lung health begins at home, the American Lung Association Health House Program’s mission is to raise the standard of the way homes are built, renovated and maintained in order to improve the indoor air quality. The American Lung Association provides guidelines to home builders for building healthier, more energy and resource efficient homes. The guidelines are reviewed annually by a technical committee composed of some of the leading indoor air quality experts in the United States. The typical components of a Health House are:

- Foundation waterproofing and moisture control.
- Advanced framing techniques.
- Air sealing and advanced insulation techniques.
- Energy efficient, high performance windows.
- Energy efficient and sealed combustion appliances.
- High efficiency air filtration.
- Whole house ventilation.
- Humidity control.
- Carefully selected and reviewed interior finishes.

All homes are site inspected during the new construction phase and performance tested upon completion. The Tribe has been working with a consultant from the American Lung Association to review house construction.

Since the 1990s, 250 tribal homes have been built according to the American Lung Association Health Home Practice. The Tribe constructs about 15 to 20 new homes a year. Tribal housing and construction crews provide quality assurance during the construction process of all new homes. The Tribe follows the city and county codes. The housing department contracts out foundation, insulation, drywall and roofing work. Tribal staff licensed in mechanical, electrical, and plumbing handle all this work along with house framing.
The following web sites provide further information on indoor air quality mold remediation.

**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*)
PART II

Sac & Fox Tribe of the Mississippi in Iowa: Meskwaki Housing Program Technical Housing Assessment Report:
Examining Mold and Moisture Conditions of Homes on the Sac & Fox Settlement.

Executive Summary

Introduction

Section 1: Methodology

Section 2: Sac and Fox Housing

Section 3: Findings

Section 4: Technical Recommendations

Section 5: Technical Discussion

Appendix A: Housing Survey Summary Site Visit Report

Appendix B: Housing Assessment Results
EXECUTIVE SUMMARY

Kate Brown, Paul Knight, and Eugene Goldfarb inspected nine homes for mold and moisture problems for the Sac & Fox Tribe of the Mississippi in Iowa, Meskwaki Housing Program (MHP) February 1 to 3, 2005.

MHP homes have been built (and continue to be built) to the American Lung Association Health House Standards which call for highly insulated homes, moisture control, efficient heating systems, and mechanical ventilation systems. MHP homes were located in an area with potentially high radon levels. Consequently, MHP homes have either a passive or active radon mitigation system. Inspected homes ranged in age from 2 years to 15 years with most homes being constructed within the past 2 to 8 years. All homes were site built with 2” x 6” framing.

The inspection process of the nine homes involved visual assessment of both interior and exterior conditions, air flow measurement of bathroom exhaust, moisture readings of wood framing members and resident interviews.

MHP reported the following problems in their homes:

- Wet crawl spaces
- Questionable performance of heat recovery ventilation (HRV) systems
- Occasional mold growth on ceilings and exterior walls

Four inspected homes had mold. Two homes had wet crawl spaces. A third home had an unreported plumbing leak that caused major structural damage and severe wetting of the crawl space. The leak was repaired in the fall of 2004, and the mold in the home may be a result of residual moisture in the home.

The fourth home had both a crawl space and basement. The crawl space was very dry, however, there was significant water damage and mold growth around the basement windows due to poor exterior window flashing.

Seven homes had heat recovery ventilators (HRVs) designed to operate on continuous basis. Exhaust air is drawn from the bathrooms at a base ventilation rate. Switches are provided in the bathrooms to boost ventilation during periods of bathing. The boost capacity was minimal or non-existent in two homes.

The remaining two homes had bathroom exhaust fans as their ventilation system.

The assessment team inspected only nine of the 300 homes managed by MHP. The findings listed below are specific to those nine homes and may not be issues in the other homes managed by MHP. Reference to these findings and subsequent recommendations should be made by MHP when similar moisture problems are encountered in other homes.
Principal Findings and Recommendations:

1. MHP was successfully solving the moisture and radon problems associated with their crawl spaces. Continue the moisture and radon remediation work in those homes not yet received it.

2. Some ceiling mold issues may be related to high indoor moisture levels as a result of crawl spaces not yet been remediated or poor insulation/air sealing over top plates (exterior wall/ceiling juncture).

3. The HRV systems controlled indoor moisture levels. Two HRV systems were found with minimal or non-existent boost capacity. Exhaust flows should be checked on all HRV systems for sufficient boost capacity.

4. Homes without HRV systems had standard bathroom exhaust fans. Replace fans as-needed with better quality exhaust fans and controls. Replace plastic ribbed ductwork used to vent clothes dryers with smooth metal ductwork.

5. Some wall mold and window condensation issues may be related to poor air circulation.

6. Overall site drainage around the homes was good. Fill localized holes and depressions. Replace missing leaders and splash blocks.

7. Occupant lifestyles can contribute to moisture and other indoor air quality issues. Lifestyle issues included turned-off HRV systems, clogged fresh air intakes on HRV systems, heavy fabrics hung over windows, blocked supply air registers and dirty HRV filters.

This 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 (BRC) 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 Meskwaki Housing Program (MHP) in central Iowa. Kate Brown (Building Research Council), Paul Knight (Magna Systems) and Eugene Goldfarb (Magna Systems) conducted the site visit from February 1 to 3, 2005. Inspected units were pre-selected by MHP.

MHP reported the following problems in their homes:

- wet crawl spaces
- questionable performance of heat recovery ventilation systems
- occasional mold growth on ceilings and exterior walls

Four inspected homes had mold. Two homes had wet crawl spaces. A third home had an unreported plumbing leak that had caused major structural damage and severe wetting of the crawl space. The leak was repaired in the fall of 2004, and the mold may be a result of residual moisture in the home.

The fourth home had both a crawl space and basement. The crawl space was very dry, however, significant water damage and mold growth around basement windows was due to poor exterior window flashing.

Seven homes had heat recovery ventilators (HRVs) designed to operate on a continuous basis. Exhaust air is drawn from the bathrooms at a base ventilation rate. Switches are provided in the bathrooms to boost ventilation during periods of bathing. The boost capacity was minimal or non-existent in two homes.

All the homes had fairly good site drainage. Localized holes and depressions around the foundations were found and an occasional downspout leader and splash block were missing.

Natural gas forced air furnaces provided the primary heating source. The water heaters were electric.

SECTION 1 – METHODOLOGY

Visual inspection was primarily used to assess mold and moisture conditions in the homes. Wood framing moisture content was measured with a moisture meter in some crawl spaces. Actual exhaust rates from HRVs and bathroom exhaust fans were measured.

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 are 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, basements 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, 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 and HRV exhaust registers 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. The pan has a variable orifice and a connection for a digital manometer. The manometer measures the pressure difference between the pan and the 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 (Figure 1).

Moisture content measurements were taken from wood members in crawl spaces where moisture was thought to be a problem. Because of the storage capacity of wood, moisture content measurements provide information on foundation and crawl space wetness in the recent past, perhaps three weeks to a month. Moisture content readings can range from 5% (very dry) to 30% (very wet).
SECTION 2 – MESKWAKI HOUSING PROGRAM

HOUSE DESCRIPTIONS

MHP managed about 300 homes on the settlement that covers approximately 7,000 acres. Nine homes were inspected. Most of the homes were constructed between 1997 and 2002. One home was 15 years old.

MHP homes had been built (and continue to be built) to the American Lung Association Health House Standards. These standards call for the following:

- Foundation waterproofing and moisture control
- Advanced framing techniques
- Air sealing and advanced insulation techniques
- Energy efficient, high performance windows
- Energy efficient and sealed combustion appliances
- High efficiency air filtration
- Whole house ventilation
- Humidity control
- Carefully selected and reviewed interior finishes

All the inspected homes were 2” x 6” construction. Sidewall insulation was not inspected and thus assumed to be R19 fiberglass batts. Inspected attics were insulated with blown fiberglass or cellulose insulation. R-values ranged between 30 and 43. Soffit and ridge vents provided attic ventilation.

Insulated concrete forms (ICF) were used for the foundations. R10 extruded polystyrene insulation boards were used as the concrete forms for the ICF system. Concrete was poured between the insulation boards and the insulation forms were left in place. Above grade insulation on the exterior was covered with parging. Interior insulation in crawl spaces was left exposed. The ICF system provided an R20 insulated foundation wall which is excellent as the interior surface temperature remains elevated and helps reduce condensation on the foundation walls during the summer and retain heat in the winter.

MHP homes were located in an area with potentially high radon levels. Consequently, MHP homes have either passive or active radon mitigation systems. Passive systems consisted of a plastic pipe that vents from below the crawl space ground cover. Where passive systems were not sufficient for mitigating radon, a continuously operating fan was installed on the vent pipe (Figure 2). A monitoring device was located in the furnace room indicating that the system maintained a negative pressure under the crawl space ground cover (Figure 3).
Air tightness of two new homes was measured in March 2004 with a blower door. A blower door is a large fan that fits within a panel assembly (Figure 4). The assembly is fitted into an exterior doorway of a home. The house was set-up for winter conditions with the furnace, water heater and HRV turned off. The fan is adjusted to depressurize the house to minus 50 Pascals (Pa), which is equivalent to a 20 mile per hour wind on all sides of the house. The amount of air that the fan is moving can be measured to determine the tightness of the home.

The two homes measured 321 CFM50 and 486 CFM50, which is quite tight. This was not a problem, however, in that HRV systems were used in the homes.

Homes exhibited a wide range of infiltration rates as measured by blower door tests. For purposes of comparison:

- In the Midwest, existing homes being weatherized average about 3500 CFM50 before weatherization.
- The Illinois Energy Efficient Affordable Housing Program requires an air leakage rate no higher than 1100 CFM50 in new homes.

Natural gas-fired forced air furnaces were the primary heating systems used in the homes. Electric water heaters were also used.

SECTION 3 – FINDINGS

3.1 Crawl Spaces

Crawl spaces can be a significant source of moisture in homes. Good site drainage and proper installation of crawl space ground covers are essential for keeping crawl spaces dry.

Seven inspected crawl spaces were very dry with well installed ground covers. Ground covers were continuous with sealed joints between sheets. Edges of the ground covers were sealed to the foundation walls. Furring strips were used to ensure that the ground cover remained attached to the foundation walls (Figure 5).
One crawl space had no ground cover and was very wet. The bandjoist, or framing lumber, was visibly wet (Figure 6). Moisture meter readings taken in framing lumber that appeared dry were in excess of 30%. This house also had indoor and attic moisture problems.

Another ground cover had unsealed joints and its edges had started to pull away from the foundation walls (Figure 7). The ground was very soft under the ground cover indicating the presence of water. Moisture meter readings taken in the floor sheathing were elevated. This home also had some interior moisture problems that became pronounced when the occupants had turned-off the HRV in January.

Radon mitigation systems were installed in the inspected crawl spaces. The systems vent the area beneath the ground covers and, as such, also help keep the crawl spaces dry (Figure 8).

3.2 Exterior Wall/Ceiling Juncture

During the winter, high indoor relative humidity combined with a cooler than desired interior surface temperature can result in condensation based mold growth on the cool surface. A common surface for this condition is at the exterior wall/ceiling juncture. This is particularly true on wood frame structures with low-sloped roof pitches. This building condition tends to restrict careful placement of ceiling insulation (reducing R-value) and is impacted by cold winds moving through the soffit vents.

Two homes had mold growth associated with hurricane clips (Figure 9). Both homes had wet crawl spaces. Metal hurricane clips on the trusses were contributing to the problem. The clips were secured to the face of the top plate.
and the side of the truss (Figure 10). Metal readily conducts heat. A combination of the cold surface and high indoor humidity levels were the cause of the mold growth.

The redesigned hurricane clips used in the new homes by the MHP secure the trusses to the top of the plate, rather than its side.

Energy trusses allowed for full height insulation over the top plates. Full height insulation reduces the potential for mold growth along the top plate. However, air from soffit vents can move through the fiberglass insulation reducing its R-value. Known as “wind-washing”, this can contribute to mold growth.

At one home some exterior work exposed the top plate condition from the outside (Figure 11). As can be seen, insulation was present over the top plate. However, there was no air barrier to prevent wind-washing through the insulation. Although mold growth due to wind-washing was not found during the site visit, this can be a potential problem and has been a problem in other Indian housing.

3.3 Heat Recovery Ventilator Systems

Seven homes had heat recovery ventilators (HRVs) designed to operate on a continuous basis.

Fresh outside air was brought into the building, filtered, conditioned and cycled through the interior spaces as one stream. The same quantity of fresh air brought in was exhausted as another stream. The exhaust air (and moisture) was drawn from the bathrooms. Heat was exchanged between the two air streams in the process. This cycle allowed for good indoor air quality that can contribute to cleaner living conditions and better health. However, the process depends on a reliable source of fresh outdoor air, adequate filtering system, and a return air exhaust.

Booster switches were included in the bathrooms (Figure 12). Switches were used to boost exhaust ventilation during period of bathing. Exhaust flow rates were measured twice; once on baseline and once on boost.
Results are shown in Table 1 (results for bathroom exhaust fans found in homes 1-7 and 2-1 are also shown).

### Table 1: Measured Exhaust Flows (CFM)

<table>
<thead>
<tr>
<th>House</th>
<th>Bathroom #1 Base</th>
<th>Bathroom #2 Base</th>
<th>Bathroom #1 Boost</th>
<th>Bathroom #2 Boost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>21 CFM</td>
<td>0 CFM</td>
<td>21 CFM</td>
<td>0 CFM</td>
</tr>
<tr>
<td>1-2</td>
<td>11 CFM</td>
<td>23 CFM</td>
<td>28 CFM</td>
<td>28 CFM</td>
</tr>
<tr>
<td>1-3</td>
<td>24 CFM</td>
<td>20 CFM</td>
<td>24 CFM</td>
<td>29 CFM</td>
</tr>
<tr>
<td>1-4</td>
<td>14 CFM</td>
<td>11 CFM</td>
<td>21 CFM</td>
<td>20 CFM</td>
</tr>
<tr>
<td>1-5</td>
<td>29 CFM</td>
<td>---</td>
<td>49 CFM</td>
<td>---</td>
</tr>
<tr>
<td>1-6</td>
<td>11 CFM**</td>
<td>35 CFM**</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1-7</td>
<td>39 CFM**</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>2-1</td>
<td>54 CFM**</td>
<td>41 CFM**</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>2-2</td>
<td>---</td>
<td>13 CFM</td>
<td>(25 CFM)</td>
<td>---</td>
</tr>
</tbody>
</table>

* - 0 CFM before filters were cleaned  
** - Exhaust Fans

The baseline ventilation in one bathroom had no exhaust flow. This same home had no increase in ventilation when the boost switch was used. The ventilation system in another home initially measured 0 CFM. The rates shown in Table 1 were achieved after the HRV filters were cleaned.

### 3.4 Bathroom and 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 two homes that did not have an HRV system. A third home had both an HRV system and bathroom exhaust fans. However, unlike other homes with HRV systems, return air was not drawn from the bathrooms.

Bathroom fans vented to the outside, except for one fan that vented into the attic (Figure 13). Measured exhaust flow rates ranged between 11 CFM and 54 CFM. The nameplate did not provide the rated exhaust flow of the fans, but is estimated to be around 70 CFM.

At a minimum, bathroom exhaust fans should provide a ventilation rate of at least 70 CFM. None of the bathroom exhaust fans were venting near this rate. It is not unique to the housing stock at MHP to have bathroom fans measuring below their rated exhaust capacity. This is commonly seen in all housing types, regardless of economic strata.
Six kitchen fans vented to the outside. The remaining three fans were recirculating. Venting kitchen exhaust fans to the outside is imperative to controlling moisture levels while cooking.

Clothes dryers vented to the outside. However, most of the dryers were vented through white plastic flex duct (Figure 14). Smooth metal ducts provide better air flow.

3.5 Wall Mold & Window Condensation

As with mold growth found at the exterior wall/ceiling juncture, high indoor relative humidity during the winter combined with a cooler than desired interior surface temperature can result in condensation based mold growth on wall and window surfaces. Increasing surface temperature or improving air flow can reduce the potential for mold growth on these surfaces.

Mold was found on walls in 4 homes. One had elevated indoor humidity levels due to a wet crawl space that may be the cause of the mold found in a closet and another had extensive mold on bedroom and closet walls. This home had a wet crawl space from a plumbing leak. In addition, a combination of high humidity and poor airflow may be contributing to the mold problem. A bed was placed over a supply air vent restricting air flow (Figure 15). Furniture and clothing items stored against a wall can also restrict air flow, especially when the clothes are placed against a closet wall (Figure 16). Another home also had residual moisture problems from a wet crawl space and a switched off HRV system.

Mold and water damage was found on walls in another home around basement windows, apparently from poor flashing on the exterior (Figure 17).

Although one home had no mold, the occupants complained of cold temperatures in the back bedrooms and window condensation problems throughout the home. The occupants also indicated that they turn-off the HRV during periods of very cold weather that can further exacerbate the window condensation problem.
Heavy fabrics were hung over the bedroom windows (Figure 18), which when closed, could restrict airflow over the window surface. However, the supply air system may be unbalanced in the bedrooms not receiving adequate air flow.

3.6 Site Drainage

Site drainage was generally good around all the inspected homes. Localized dips and holes around foundations and an occasional missing leader and splash block allowed some pooling of water (Figure 19). These items did not appear to be causing any moisture problems in the crawl spaces.

One home had especially good site drainage. A hill was located at the back of the home. A swale was grooved in the ground between the hill and home to direct rainwater and snow melt away from the home (Figure 20). Although this home had very wet ground under the crawl space ground cover (and the ground cover was not continuous and sealed), the problem could have been much more severe without the site drainage in the back of the home.

3.7 Occupant Lifestyles

Occupant lifestyles may also contribute to moisture and other indoor air quality issues.

Heavy drapery covering windows, timely reporting and repairing plumbing leaks, blocked supply air registers, overstuffed closets and dirty HRV filters were specific observations made during the site visit.

Occupants should be educated 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 the following:

- dirty HRV filters
- clogged fresh air intakes
- reports that HRVs are occasionally turned off
- heavy window coverings
Overcrowding is a fairly common problem in Indian housing, although apparently not an issue in the homes visited at MHP. While often unavoidable, overcrowding should be recognized as a major contributor to indoor humidity levels. High occupancy levels increase the moisture loads from human activities (breathing, cooking, washing, etc.). Elevated interior moisture loads can lead to mold contamination from condensation problems.

SECTION 4 – TECHNICAL RECOMMENDATIONS

The following recommendations are based on the site visit findings.

4.1 Crawl Spaces

Crawl space remediation work similar to that found in 2 homes should continue in homes without ground covers.

- If present, seal and make existing crawl space vents watertight.
- Inspect and replace missing rim joist insulation. This inspection should also be done in basements.
- Cover the soil surface in the crawl spaces with a continuous ground cover and seal with a polyethylene sheet of other vapor-proof material.
- Lap and seal the joints between pieces of the ground cover with sheathing tape.
- Seal the edges of the ground cover to the foundation wall with both sheathing tape and furring strips.
- Inspect the crawl spaces on a periodic basis to ensure that ground covers are sealed and secured to the foundation walls.
- Encourage occupants to keep their crawl spaces free of clutter and not to use as storage spaces.

4.2 Exterior Wall/Ceiling Juncture

Although not a significant problem in MHP housing, some localized mold growth at this juncture was found, especially when hurricane clips were used and the homes had wet crawl spaces.

- Recommendations are made with respect to controlling indoor moisture levels and improving the insulation and air sealing over top plates.
- Recommendations with respect to crawl space ground covers, ventilation and site drainage should be carefully checked.
- Remove existing fiberglass insulation over top plates. Use two-part spray foam to cover exposed hurricane clips (Figure 21). The two-part spray foam may also be used to air seal between top plate and insulation baffle. Replace fiberglass insulation.

Spray polyurethane foam has an R-value of 6 per inch. It is also impermeable to air flow. The foam should provide the necessary insulation and air seal to elevate the interior surface temperature of the wall/ceiling juncture and especially the hurricane clips.

**4.3 Heat Recovery Ventilator Systems**

The HRV systems in MHP housing are excellent ventilation systems (Figure 22). They should continue to be installed in new housing and in existing homes that were built without them.

- The systems appear well designed and effective in providing fresh air to all of the living spaces while exhausting air from the bathrooms.
- Instruct occupants on importance of using HRV systems and cleaning filters on a regular basis.
- Inspect fresh air intakes on a regular basis and clean as necessary.
- Periodically check flow rates from exhaust ports, both on baseline and on the boost setting. Balance systems as needed.

**4.4 Bathroom and Kitchen Exhaust Fans; Clothes Dryers**

Bathrooms and kitchens generate large amounts of moisture. Properly operating exhaust fans and HRV systems remove moisture from these spaces.

Replace non-operable or poorly operating bathroom exhaust fans in homes that do not have HRV systems.

- Fans should be rated 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. Use round, smooth sheet metal ductwork. Minimize length, turns and bends in the ductwork. Smooth duct provides less resistance and improved flow over ribbed ductwork. Recommend that occupants clean intake grilles of dust and lint as needed.

• Replace fan on/off switches with 60 minute timer switches. Recommend that fans operate for at least 15 minutes following showers or baths. 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. When the switch is turned-on, both the light and exhaust fan are turned-on. When the switch is turned-off, the light is turned-off but the fan continues to operate for an extended period of time. The extended period of time can be adjusted 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.

• As rehabilitation work is done in laundry rooms, replace flex duct with smooth metal duct work (Figure 23). Install duct to minimize bends and elbows.

• 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 recirculating kitchen fans with fans vented to the outside as rehabilitation work is done in these kitchens. Minimum exhaust capacity should be 150 CFM.
4.5 Wall Mold & Window Condensation

The following recommendations improve air flow in the bedrooms:


- Avoid blocking supply air vents with furniture or clutter.

- Consider replacing solid panel closet doors with louvered doors.

- Measure supply air CFM at bedroom registers with a velometer (range is 70 CFM to 100 CFM, depending on bedroom size). Damper system to increase airflow.

4.6 Site Drainage

Site drainage was generally good at the inspected homes.

- Fill in the small holes and dips found adjacent to foundations.

- Grade directly at the foundation to ensure a soil pitch away from the homes of at least 5% (6 inches per 10 feet).

- Replace missing downspout leaders and splash blocks.

4.7 Occupant Education

Occupant lifestyles may also contribute to moisture and other indoor air quality issues. Educate occupants in the following areas to solve and eliminate moisture problems:

- Avoid using heavy blankets to cover windows. Use louvered blinds to allow airflow to wash the surface area of windows. If blankets continue to be used, keep the blankets off the windows as much as possible.

- Change furnace filters monthly.

- Clean HRV filters monthly.

- Keep the HRV systems operating.

- Use bathroom and kitchen exhaust fans for a minimum of 20 minutes following showering or bathing.

- Report plumbing leaks to the housing office as soon as possible.
SECTION 5 – DISCUSSION OF COMMON PROBLEMS

5.1 Crawl Space Design

The thermal boundary is the building section that separates conditioned space from outside conditions. A clear distinction should be made whether the crawl space walls or the floor above the crawl space is the thermal boundary for any home with a crawl space. 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.

It was clear that the crawl space walls form the thermal boundary in MHP homes. The foundations were insulated concrete forms (ICFs) and the crawl spaces were not vented. In essence, the crawl space is designed as a stubby basement that is conditioned as a result of ductwork being located there. Some crawl spaces are designed with an open supply air register to further help condition it. Return air should not be drawn from a crawl space. The team recommends that the crawl space foundation walls continue to be the thermal boundary in new home construction.

The following recommendations relate to crawl spaces, regardless of thermal boundary:

- Ensure easy access to crawl spaces and good lighting for regular inspections.
- Never locate return air grilles in crawl spaces.
- Water in crawl spaces typically comes from poor rainwater management outdoors, plumbing leaks, air conditioner condensate or water softener discharge.
- Cover the ground surface with a ground material; either a concrete slab, a polyethylene sheet or other vapor-proof material. Seal the ground cover to the foundation walls and to foundation piers interior to the crawl space. Seal all joints and seams.

5.2 Exterior Wall/Ceiling Juncture

High relative humidity and cold surfaces can lead to mold growth. If a surface approaches the dew point temperature based on the relative humidity, water will condense, be quickly absorbed by the material, and raise the moisture content of the surface. At some point, the moisture content can be sufficient to promote mold growth. This process often occurs at the wall/ceiling junction on exterior walls.

There are at least three reasons why the exterior wall/ceiling juncture gets cold:

1. Cold wind may enter through soffit vents and pass through the porous insulation material, degrading its thermal performance.
2. The insulation may have been poorly installed resulting in reduced amounts of insulation over the plate.

![Diagram of wall-ceiling corners]

Figure 24: Wall-ceiling corners are cold because of 1. Wind movement through soffit vents, 2. Smaller amounts of insulation at the corner and 3. Corner is outside the movement of warm air currents indoors.

3. The geometry of the corner usually prevents slow-moving currents of warm air from reaching into the corners (Figure 24).

The dark spots occur where the interior surfaces are the coldest, especially if hurricane clips are used to hold down the trusses. They occur there because that is the hardest place to insulate effectively. It is difficult to carefully insulate the exterior edge of the attic, especially in homes with low-pitch roofs. With batt insulation, special pusher sticks may be used to get the insulation out to the edge. With loose fill insulation, the outside edge should be prepared correctly so that it is packed with insulation.

Many individuals and organizations (including model codes) stress the importance of attic ventilation. While it has some benefits, it also has some drawbacks. Wind washing of insulation at the edge is one of the major drawbacks. Designs without attic ventilation...
may improve the performance of the eave area, and most designs without ventilation rely on verified airtightness of the ceiling plane for good moisture performance. For more information about the benefits and drawbacks of attic ventilation see “Venting of Attics and Cathedral Ceilings” (http://brc.arch.uiuc.edu/billrose/issues.pdf). Attic vents are, however, recommended for cold climates such as Iowa to help minimize ice dams. Attic ventilation appeared to be sufficient in the inspected homes' attics.

5.3 Heat Recovery Ventilation Systems

In cold winter climates, excess airborne water vapor (relative humidity) can be considered a pollutant with the potential for contributing to mold contamination. The purpose of an HRV is to provide fresh outdoor air for dilution of pollutants and improved indoor air quality. In the process of bringing fresh air into a building and exhausting stale air from the building, an HRV passes the two airstreams simultaneously through a heat recovery core, thus recapturing some of the heat (estimated between 50% and 80%) that would otherwise be exhausted with the stale air. Mechanical ventilation augments the natural infiltration of outside air that occurs in buildings. In tight buildings with limited natural infiltration such as MHP homes, mechanical ventilation can serve an important role in the dilution of airborne water vapor, and thus reduce the potential for interior mold contamination.

For the most effective operation, a mechanical ventilation system should supply fresh air to all the main living spaces, such as bedrooms, living, dining and family rooms. The distribution should be designed to ensure mixing of the fresh air and provide balancing of the distribution system. Exhaust should remove air from spaces in which moisture and odor are generated, generally kitchens, bathrooms and utility rooms.

The HRV systems in MHP homes functioned properly.

5.4 Bathroom and Kitchen Exhaust Fans/Dryer Vents

Several rooms in a home are natural moisture sources simply by the nature of their function. Showers are taken in bathrooms resulting in 100% humidity in that room. Kitchens are used for cooking and cleaning. In laundries, clothes dryers must remove large quantities of water from wet 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 house 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 basement, 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, the greater the static pressure in the duct and the less air flow through the duct. Turns and bends in the ductwork also increase the static pressure and reduce flow. Similarly, a smooth duct provides less resistance and improved flow over ribbed ductwork. 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 range hoods whenever possible with mandatory venting to the outside. The hoods should have a minimum exhaust capacity of 150 CFM. Under no circumstances reinstall recirculating fans.

Dryer vents should be smooth-surfaced rigid duct. Non-combustible flexible metal duct approved for dryer venting may also be used. Duct joints should be in the direction of air flow. 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 non-conditioned spaces.

Minimum duct diameter should be 4 inches and length should not exceed 25 feet from the dryer outlet to the termination point. If duct length is greater than 25 feet, use 5 inch diameter duct.

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.

5.5 Air Flows

An improperly balanced air-handling system can cause comfort, building durability, and indoor air quality problems. An air flow test measures pressure differences between the bedrooms and main body of the home. Pressure differences greater than ±2.0 Pa or more negative than -2.0 Pa should be corrected. The test is conducted with a manometer while the furnace air handler is operating, in the following manner:
- Set-up home for winter conditions. Close all windows and exterior doors. Turn off all exhaust fans.

- Close all interior doors, including the door to the basement.

- Turn on the air handler.

- Place a hose from the “input” tap on the manometer under the door. Leave “reference” tap open to the main body of the home.

- Read the measurement for each room (Figure 25).

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 needed, 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:

- Undercutting the doors

- Installing transfer grilles (Figure 26)

- Retrofit 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.

The previous test measures the pressure difference between a room and the main body of the house. It does not measure actual flow, or CFM, coming out of the supply air register. A velometer (Figure 27) can be used to measure actual flow. Most heating contractors should have this device.

5.6 Site Drainage

When rain falls on a building site, where should the water go? The roof should be designed and built so that the water that lands on the roof is moved out to the edge of the roof. When rain falls on a soil surface, some of it will percolate downward through
the soil—more in sandy soils and less in clayey soils. The water that does not percolate downward will move along the soil surface following the slope, out to the downhill edge of the site. The best way to prevent mold and moisture problems in houses is to make sure that rainwater moves off the roof and across the site and off the property. The houses that have problems are the houses that allow water to accumulate in the soil that is in contact with the foundation. The soil that is in contact with the foundation should, in a well-managed property, be the driest soil on the site following a rainstorm. Houses with dry foundations (basements, crawl spaces and slabs) are usually dry houses. Keeping the foundation dry is the key to a good indoor environment in most houses. To keep the foundation dry, keep the soil dry that is next to the foundation.

Keeping the soil that touches the foundation dry involves a few general rules, together with some specific guidelines.

The first general rule is the rule of 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.

The second general rule is the “ground-roof” rule - treat the soil surface as if it were a low-slope roof surface. Pitch the surface away from the house - the steeper the pitch, the better the drainage. If all the water is to move to the low edge of the site, how best would it get there. Avoid areas near the building that can act as water collectors.

Specific site drainage guidelines include:

- The home should be built on a crown, not in a hole. If there is sufficient exposed foundation, site grading at the home can be improved. If the home hugs the ground, improvements at the foundation are more difficult. There should be a minimum of eight inches of exposed foundation between the ground and the beginning of the siding.

- 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.

- If the home has no gutters, then the base of the soil around the home has to serve as a gutter itself. It should have a surface that helps prevent splash back onto the siding of the house. It should be designed with pitch so that it effectively moves water away from the house.
• Good tamping or compaction of the backfill is very helpful because it helps keep 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.

• Bushes and other plantings may be very helpful, especially if their root balls soak up a lot of water. Also they can be planted strategically near downspouts so that the downspout extenders are less likely to be kicked off or removed during lawn mowing.

5.7 Occupant Items

A number of identified occupant items 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?
- Importance of maintaining and using HRV systems.
- Use of bathroom and kitchen exhaust fans.
- Use of crawl spaces and not storing items in them.
- Changing furnace filters.
- Prompt reporting plumbing leaks and water condensing on pipes.
- Keeping supply air registers open and not blocked by furniture or household items.
## SUMMARY SITE VISIT REPORT

**DATE:** February 1-3, 2005

<table>
<thead>
<tr>
<th>Inspection Number</th>
<th>Address</th>
<th>HUD Program</th>
<th>Building Age</th>
<th>Occupancy</th>
<th>Foundation Type</th>
<th>Model and Framing Type</th>
<th>Heat Type</th>
<th>Site Drainage Problems</th>
<th>Gutter System Problems</th>
<th>Leaks from Exterior</th>
<th>Wet Basement or Crawl Space</th>
<th>Plumbing Problems</th>
<th>Exterior wall/ceiling problems</th>
<th>Attic Problems</th>
<th>Visible Mold (Column #)</th>
<th>CFM (boost)</th>
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<td>5</td>
<td>Crawl Space - ICF</td>
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<td>Yes</td>
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1. Insulated concrete forms
Appendix B: Sac & Fox Tribe of the Mississippi in Iowa

Inspection Number: 1-1
Address: 688 Meskwaki Rd.
Age: 8
House Type: Split-level
Occupancy: 5
Bedrooms: 3
Foundation: Insulated concrete forms; crawl space
Heat Type: FA furnace (propane)
Construction: Stick-built, 2" x 6"

Mold and Moisture Conditions: The crawl space was very wet (Figure 2) from the saturated ground (high water table). There was no ground cover, thus moisture from the ground penetrated all areas of the home. The floor sheathing and bandjoist were visibly wet (Figure 3). Floor sheathing and joists that appeared dry were saturated with moisture when measured with the moisture meter.

Signs of moisture condensation appeared on the kitchen ceiling. The locations of condensation corresponded to the joist locations (Figure 4). Mold was also found on a closet wall and on some window stools.

The attic over the lower level of the home was visibly dry. The attic over the upper level of the home had wet sheathing (Figure 5). Mold grew on the insulation dam around the attic hatch and on some of the roof trusses.

Rainwater Management: Site drainage was fairly good. Minor holes and depressions were found around the home. The gutter system was in good condition.

Figure 1 – 688 Meskwaki Rd.
Figure 2 – Wet crawl space
Figure 3 – Wet bandjoist
Figure 4 – Mold on kitchen ceiling
Figure 5 – Wet roof sheathing in upper level attic
Crawl Space: As previously noted, the crawl space was very wet. An area of the bandjoist directly beneath the front door was particularly wet with icicle type growth on the floor sheathing (Figure 6). Water entry may be occurring at the door where the flooring had pulled away from the threshold (Figure 7). The bandjoist was uninsulated.

Bathroom/Kitchen: The kitchen fan was recirculating. The bathrooms were continuously vented with the HRV system. Baseline ventilation from the lower level bathroom and upper level bathroom was 21 CFM and 0 CFM, respectively. There was no change in the ventilation rates when the booster switches were activated. The dryer vented to the outside through plastic flex duct.

Attic: Both attics were insulated with approximately 13” of blown fiberglass insulation. The OSB insulation dam around the upper level attic hatch was moldy (Figure 8). Roof sheathing and some of the trusses were visibly wet.

Heating System: The furnace was direct vent sealed combustion with a seasonal efficiency of 90%. The water heater was electric. The HRV system was located in the furnace room.

Occupant Notes: Five people lived in the home.

Recommendations:

The major source of moisture in the home was from the damp crawl space. That, in addition to inadequate bathroom ventilation, was the likely cause in interior mold growth on walls, ceiling and windows. Removing the moisture source and improving the continuous ventilation system with these recommendations will likely improve the situation:

- Install sealed ground cover in the crawl space.
- Insulate the bandjoist with minimum R19 insulation.
- Inspect the exhaust duct from the upper level bathroom to determine why there is no exhaust flow.
• Inspect the HRV system controls to determine why there is no boost capacity from either bathroom.

• Airseal the hatch to the upper level attic.

• Remove attic insulation from the top plates where interior condensation is occurring. Insulate and air-seal over the plate with two-part spray foam, especially where metal hurricane clips are used. Replace insulation while maintaining 1” air space between insulation and bottom side of roof deck.

• Vent kitchen fan to the outside.

• Replace plastic exhaust duct for dryer with metallic flex or smooth metal.
Inspection Number: 1-2
Address: 500 Red Earth Drive
Age: 5
House Type: Split-level
Occupants: 4
Bedrooms: 4
Foundation: Insulated concrete forms; crawl space
Heat Type: FA furnace (natural gas)
Construction: Stick-built, 2” x 6”

Mold and Moisture Conditions: Window leaks had been corrected. Some leaders and splash blocks were missing at the downspouts. No water or mold problems were found in the home. Filters on the HRV system were very dirty.

Rainwater Management: Missing leaders and splash blocks were causing some pooling of water near the foundation (Figure 2).

Crawl Space: The crawl space was unvented, had a sealed ground cover (Figure 3) and was very dry. The bandjoist behind the fiberglass insulation was very dry.

Bathroom/Kitchen: The kitchen fan vented to outside. The HRV filters were very dirty. The ventilation rate for the lower level bathroom was 0 CFM before the filters were cleaned. The ventilation rates were measured after the filters were cleaned. The ventilation rates for the lower and upper level bathrooms were 11 CFM and 23 CFM, respectively. The ventilation rates for both bathrooms measured 28 CFM on boost.

Attic: The attic was insulated with approximately 9” of blown cellulose insulation. The attic was very dry with no visible signs of moisture or mold (Figure 4).

Heating System: The furnace was direct vent sealed combustion with a seasonal efficiency of 90%. The water heater was electric. The HRV system was
located in the furnace room. Ducts were well sealed with duct mastic (Figure 5).

**Occupant Notes:** Four people lived in the home.

**Recommendations:**

No mold or moisture problems were found in the home, but the following recommendations apply:

- Install leaders and splash blocks where needed on downspouts.
- Encourage occupant to clean HRV filters on a regular basis.

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Figure 5 — Duct joints sealed with mastic
Appendix B: Sac & Fox Tribe of the Mississippi in Iowa

February 1-3, 2005

Inspection Number: 1-3
Address: 2997 F Avenue
Age: 8
House Type: Split level
Occupants: 8
Bedrooms: 3
Foundation: Insulated concrete forms; crawl space
Heat Type: FA furnace (natural gas)
Construction: Stick-built, 2” x 6”

Mold and Moisture Conditions: A prior mold problem had been corrected in this home. The water heater was leaking, leaving some standing water near the water heater that had spread under the common wall between the furnace room and the space near the crawl space access hatch. No other water or mold problems were found in the home. Some leaders and splash blocks were missing at the downspouts.

Rainwater Management: Missing leaders and splash blocks were causing some pooling of water near the foundation (Figure 2).

Crawl Space: The crawl space was unvented, had a sealed ground cover and was very dry. The bandjoist behind fiberglass insulation was very dry.

Bathroom/Kitchen: The kitchen fan vented to the outside. The bathrooms were continuously vented with the HRV system. Baseline ventilation measurement from the lower level bathroom and upper level bathroom was 24 CFM and 20 CFM, respectively. No change occurred in the ventilation rate for the lower level bathroom when the booster switch was activated. The ventilation rate for the upper level bathroom increased to 29 CFM with the booster switch.

Attic: The attic was insulated with approximately 9” of blown fiberglass insulation. The attic was very dry with no visible signs of moisture or mold. Raised heel trusses were used in the attic to decrease the potential for condensation over the top plates (Figure 3).
**Heating System:** The furnace was direct vent sealed combustion with a seasonal efficiency of 90%. The water heater was electric and was leaking (Figure 4). The HRV system was located in the furnace room. The home also had an active radon mitigation system (Figures 5 & 6). The dryer vented to the outside with plastic duct work.

**Occupant Notes:** Eight people lived in the home.

**Recommendations:**

No mold was found in the home. The most significant problem was the leak in the water heater, thus these recommendations:

- Replace the water heater.
- Inspect the exhaust duct from the lower level bathroom to determine why there is no exhaust flow.
- Install leaders and splash bocks where needed on the downspouts.
- Replace the plastic exhaust duct for the dryer with metallic flex or smooth metal.
Appendix B: Sac & Fox Tribe of the Mississippi in Iowa February 1-3, 2005

Inspection Number: 1-4
Address: 202 Red Earth Drive
Age: 4
House Type: Two-story
Occupants: 8
Bedrooms: 4
Foundation: Walk-out basement
Heat Type: FA furnace (natural gas)
Construction: Stick-built, 2" x 6"

Mold and Moisture Conditions: Occupants complained that the back bedrooms become cold during periods of very cold weather. Occupants turned off the HRV system to avoid bringing cold air into the home. Condensation has also been a problem on the back bedroom windows, compounded by heavy fabrics used to cover the windows (Figure 2). When closed, fabrics of this nature restrict air flow across the window surface. No mold or moisture problems were found in the home.

Rainwater Management: The site drainage and gutter system were satisfactory.

Basement: The home had a dry walk-out basement.

Bathroom/Kitchen: The kitchen fan vented to the outside. The bathrooms were continuously vented with the HRV system. Baseline ventilation from the lower level bathroom and upper level bathroom was 14 CFM and 11 CFM, respectively. The ventilation rates increased to 21 CFM (lower level bathroom) and 20 CFM (upper level bathroom) when the booster switch was activated.

Attic: The attic was insulated with approximately 9" of blown cellulose insulation and was very dry with no visible signs of moisture or mold (Figure 3).

Heating System: The furnace was direct vent sealed combustion with a seasonal efficiency of 90%. The water heater was electric. The HRV system was located in the...
furnace room. The dryer was vented to the outside with smooth metal duct work (Figure 4).

**Occupants:** Eight people lived in the home.

**Recommendations:**

No mold or moisture problems were found in the home. The most significant problem, a comfort problem in the back bedrooms during period of very cold weather, could be remedied with the following:

- Inspect the supply air duct work to the back bedrooms to ensure adequate air flow. This can be done with a velometer that most heating contractors have. Velometers measure CFM air flow coming out of the duct work.
- Encourage occupants to use lighter window coverings.
- Ensure that furniture does not block the supply air registers.
Appendix B: Sac & Fox Tribe of the Mississippi in Iowa

Inspection Number: 1-5
Address: 231 Edgewood Drive
Age: 2
House Type: Ranch
Occupants: 2
Bedrooms: 4
Foundation: Insulated concrete forms; crawl space
Heat Type: FA furnace (natural gas)
Construction: Stick-built, 2” x 6”

Mold and Moisture Conditions: The crawl space moisture problem has been corrected. No mold or moisture problems were found.

Rainwater Management: Site drainage around the home was good, although some leaders and splash blocks were missing (Figure 2).

Crawl Space: The crawl space was dry, with a continuous ground cover and active radon mitigation system installed (Figure 3).

Bathroom/Kitchen: The kitchen fan was recirculating. The ventilation rate from the bathroom was 29 CFM and 49 CFM on the booster.

Attic: The attic was insulated with approximately 9” of blown fiberglass insulation. The attic was very dry with no visible signs of moisture or mold.

Heating System: The furnace was direct vent sealed combustion with a seasonal efficiency of 90%. The water heater was electric. The HRV system was located in the furnace room. The exterior intake to the HRV was clogged with debris (Figure 4).

Occupants: Two people lived in the home.

Recommendations:

Recommendations include the following:

- Install downspout leaders and splash blocks.
- Check and clean the HRV intake regularly.
Appendix B: Sac & Fox Tribe of the Mississippi in Iowa

**Inspection Number:** 1-6
**Address:** 1542 Highway 30
**Age:** 15
**House Type:** Ranch
**Occupants:** 2
**Bedrooms:** 2
**Foundation:** Insulated concrete forms; crawl space
**Heat Type:** FA furnace (natural gas)
**Construction:** Stick-built, 2” x 6”

**Mold and Moisture Conditions:** Mold grew on the north side of the home following the installation of an active radon mitigation system (Figure 2), which vented from the crawl space through the north wall. The exhaust for the radon mitigation system has since been extended up through the roof (Figure 3).

The mold growth around the original radon vent occurred because the actively venting radon vent brought moisture from the area under the crawl space ground cover up, continuously wet the siding. Furthermore, since the north side of the home received little sun, the siding tended to stay wet. The extension of the exhaust up and over the roof eliminated the wetting of the siding. It should be noted, however, that mold growth on the north side of other homes was also found during this site visit.

**Rainwater Management:** Site drainage around the home was good. Some leader extenders were added to move water away from the home (Figure 4).
Crawl Space: The crawl space had a continuous and sealed ground cover. The bandjoist insulation was rigid foam insulation with spray foam as an air seal (Figure 5). The crawl space was dry.

Bathroom/Kitchen: The kitchen fan was recirculating. This home had no HRV system. Standard exhaust fans were used in each bathroom. Measured exhaust was 11 CFM and 35 CFM in each bathroom. Both fans were rated at 50 CFM.

Attic: The attic was insulated with 9 inches of cellulose. No visible mold or moisture was found in the attic.

Heating System: The furnace was direct vent sealed combustion with a seasonal efficiency of 90%. The water heater was electric. The dryer was vented to the outside through plastic flex duct.

Occupants: Two people lived in the home.

Recommendations:

Except for the exterior of the north wall, no mold or moisture problems were found in the home. Recommendations include the following:

- Pressure-wash the north side siding to remove mold and mildew.
- Replace the dryer plastic flex duct with a smooth metal duct.
- When remodeling is finished in the kitchen, replace the recirculating hood with a vented kitchen hood that exhausts outside.
- Consider installing mechanical or fan-delay timers as bathroom exhaust fan controls.
- Replace the exhaust fans with low sone fans rated at 70 CFM @ 0.25” of static pressure when remodeling the bathroom.
Appendix B: Sac & Fox Tribe of the Mississippi in Iowa

February 1-3, 2005

Inspection Number: 1-7
Address: 1536 Highway 30
Age: 9
House Type: Ranch
Occupants: 4
Bedrooms: 3
Foundation: Insulated concrete forms; crawl space
Heat Type: FA furnace (natural gas)
Construction: Stick-built, 2” x 6”

Mold and Moisture Conditions: A kitchen plumbing leak in the fall of 2004 had caused significant structural damage to the floor (Figure 2). The damage had been repaired and the crawl space was dry. Mold growth was found on the west wall of the bedroom and on two exterior walls in closets (Figure 3). A bed partially blocked the supply air in register. The residents had stored items against the closet walls (Figure 4).

Rainwater Management: Site drainage around the home was generally good. Some leader extenders were missing (Figure 5) and one gutter was damaged, apparently from ice (Figure 6).

Crawl Space: The crawl space was dry, but damage due to the kitchen sink leak was very apparent. The dryer vented to the outside through a
Appendix B: Sac & Fox Tribe of the Mississippi in Iowa

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combination of plastic and metallic flex duct (Figure 7).

**Bathroom/Kitchen:** The kitchen fan vented to the outside. This home had no HRV system. A standard exhaust fan was used in the bathroom, with measured exhaust of 39 CFM. Both fans were rated at 50 CFM.

**Attic:** The attic was insulated with 9 inches of blown fiberglass. No visible mold or moisture was found in the attic.

**Heating System:** The furnace was direct vent sealed combustion with a seasonal efficiency of 90%. The water heater was electric.

**Occupants:** Four people lived in the home.

**Recommendations:**

Although the kitchen leak had been fixed, the home may still have residual moisture causing the mold growth on the bedroom and closet walls. Follow the recommendations below to enhance the drying of these surfaces:

- Remove furniture blocking supply air registers.
- Measure air flow to bedrooms with velometer and balance the system as needed.
- Keep stored items at least 1 inch away from the exterior walls to facilitate air flow.
- Consider replacing solid panel closet doors with louvered doors to allow air circulation in closets.
- Encourage occupant use lighter weight window coverings to facilitate drying of window surfaces.
- Replace the dryer exhaust duct with a smooth metal duct.
- Replace the missing leaders and splash blocks.
- Replace the damaged gutter on the back of the home.
- Consider installing mechanical fan-delay timer as a bathroom exhaust fan control.
- Replace the exhaust fan with low sone fan.
Appendix B: Sac & Fox Tribe of the Mississippi in Iowa

February 1-3, 2005

Inspection Number: 2-1
Address: 3033 F. Ave.
Age: 11
House Type: Two-story
Occupants: 5
Bedrooms: 4
Foundation: Insulated concrete forms; crawl space and a converted basement
Heat Type: FA furnace (natural gas)
Construction: Stick-built, 2” x 6”

Mold and Moisture Conditions: Mold was found on the upper level bathroom ceiling and around windows in the two lower level bedrooms (Figure 2). Ceilings above the windows were also moldy. Some wood trim had buckled (Figure 3).

Rainwater Management: Site drainage around the home was generally good. The exterior finish over the lower level window flashing was cracked and missing in some cases. Windows had inadequate header flashing (Figure 4).

Crawl Space: The crawl space under the addition was dry.

Lower Level: The lower level was a basement converted to living space. Mold was found around the basement windows and ceiling. It appeared the water leaking from the exterior around the window rough opening was the cause of the problem. A significant number of lady bugs also indicated air leakage around the window. Cold air will lower the surface temperature of the wall, ceiling, and window trim increasing the potential of mold growth.

Bathroom/Kitchen: The kitchen fan vented to the outside. Mold growth on the ceiling. This fan vented into the attic (Figure 5). The upper level fan measured 41 CFM and the lower level measured 54 CFM.

Attic: The dry attic was insulated with 9 inches of cellulose insulation.

Occupants: Five people lived in the home.
Appendix B: Sac & Fox Tribe of the Mississippi in Iowa
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**Recommendations:**

The most significant problem appears to be water entry around the lower level basement windows, which may be remedied with the following:

- Replace (or re-install) lower level windows utilizing proper flashing.
- Seal rough openings with low expanding foam following installation of windows to reduce air leakage.
- Vent the bathroom fan to the exterior through smooth metal duct.
- Consider installing mechanical or fan-delay timers as bathroom exhaust fan controls.
- Replace exhaust fans with low sone fans rated at 70 CFM @ 0.25” of static pressure when remodeling the bathroom.
Appendix B: Sac & Fox Tribe of the Mississippi in Iowa

Inspection Number: 2-2
Address: 150 West Village
Age: 8
House Type: Two-story
Occupants: 5
Bedrooms: 4
Foundation: Insulated concrete forms
Heat Type: FA furnace (natural gas)
Construction: Stick-built, 2” x 6”

Mold and Moisture Conditions: Windows had condensation problems in January as a result of the HRV system being turned off. When the HRV was turned on, the condensation problem disappeared.

Mold was found behind a plastic vapor barrier and at the base of an exterior door on the lower level. A small amount of mold was found on the ceiling in the kitchen. Although there was a ground cover in the crawl space, it was not continuous. The ground under the cover was very soft. Mold was growing on the north side of the home (Figure 2).

Rainwater Management: Site drainage around the home was generally very good. There is a hill at the back of the home. A swale is used to direct water away from the home (Figure 3). Some leaders and splash blocks were missing.

Crawl Space: The crawl space had some standing water on the ground cover. The ground cover was not continuous and was beginning to pull away from the foundation walls (Figure 4). The ground was very wet under the cover. Moisture readings in the framing and floor sheathing indicated that the wood was dry. The bandjoist was not insulated.

Lower Level: Some flooding had occurred near the lower level door. Water stains were visible on the wall (Figure 5) as well as...
behind the polyethylene vapor barrier on the wall (Figure 6).

**Bathroom/Kitchen:** The kitchen fan vented to the outside. Mold was visible on the kitchen ceiling under trusses as a result of the “hurricane clips” (Figure 7). The upper level bathroom measured 13 CFM and 25 CFM on boost. The lower level bathroom was inaccessible.

**Attic:** Attic was insulated with 10 inches of blown fiberglass. No signs of mold or moisture were seen in the attic.

**Occupants:** Five people live in the home.

**Recommendations:**
Potential moisture problems may result from the unsealed ground cover. The ground under the crawl was very wet. This moisture may eventually find its way into the home. Also, it was apparent that the HRV is needed to keep moisture levels from becoming excessive in the home.

- Repair ground cover sealing all joints and securing perimeter to foundation wall.
- Insulate bandjoist with minimum R19 insulation.
- Slash polyethylene vapor barrier to allowing drying of the wall on the lower level.
- Replace missing leaders and splash blocks. Ensure positive drainage away from lower level exterior door.
- Remove attic insulation from top plates where interior condensation is occurring. Insulate and air-seal over plate with two-part spray foam, especially metal “hurricane clips”. Replace insulation while maintaining 1” air space between insulation and bottom side of roof deck.