BAD RIVER TRIP REPORT

Assessment of Mold and Moisture Conditions

Final Report

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Prepared for:
U.S. Department of Housing & Urban Development
Office of Native American Programs

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TABLE OF CONTENTS

INTRODUCTION

Jeff Gordon and Bill Rose from the Building Research Council (BRC) at the University of Illinois Urbana-Champaign and Robert Nemeth of Magna Systems conducted a site visit at Bad River Reservation on December 3-4, 2002. The purpose of the site visit was to provide technical assistance to the Bad River Housing Authority in assessing mold and moisture condition in housing units. This is a summary report of activities and issues addressed while on site. A detailed analysis of the findings and recommendations is found in the attached reports, entitled: *Technical Housing Assessment Report: Examining Mold and Moisture Conditions of Homes on the Bad River Reservation.*

BACKGROUND INFORMATION

The Bad River Reservation is located in Ashland and Iron counties in the northern section of the State of Wisconsin. The region's winter climate consists of cold temperatures and heavy snowfall. The region has many lakes, streams, and rivers along with wetlands and marshes. Tribal staff reported high water tables. This type of topography can contribute to mold and moisture conditions. There are about 2,086 Native Americans residing on the reservation. The housing authority maintains 167 Low Rent homes, 24 Mutual Help homes and 1 Turnkey home.

Upon completion of the inspections, the team traveled to Ashland, WI and Hal Beiler, Grants Management Specialist of E/WONAP at HUD, participated in the remainder of the activities on the trip.

Day 1: Tuesday, December 3, 2002

On Tuesday morning, the assessment team met with the Bad River Housing Authority staff to discuss the day's activities, outline the team's role while on the reservation, and address the Tribe's concerns regarding the site visit. Present at the meeting were Mary Maday, Bad River Housing Director, and staff members Donald Neveaux and Bruce Ford of the Housing Authority's building and maintenance staff, Bill Rose and Jeff Gordon from the Building Research Council, Robert Nemeth from Magna Systems, Hal Beiler from HUD's E/WONAP, and Indian Health Service Staff: Casey Crump, Rhinelander District Environmental Health Officer; Diane Kuklinski, Acting Division Director for Bemidji Environmental Health Services; Dick Reese, Northern American Health Alliance Environmental Health Officer; and Carolyn Garcia, Rhinelander District Service Unit Environmental Health Officer.

Mary Maday, Bad River Housing Director, reported mold and moisture problems with homes on the reservation. Currently, there are 206 units under the housing authority's direction, with ten more units under construction. Ms. Maday stated that approximately sixty units had reported some type of mold problem.

After the meeting, the assessment team began the on-site inspections. Donald Neveaux and Bruce Ford, the Bad River Housing Authority staff, accompanied the assessment team on Tuesday. The Housing Authority selected the properties to be inspected. The inspection staff was divided into two inspection teams. Digital photographs were taken at each site to record conditions. The inspection process involved visual assessment of both interior and exterior conditions, moisture content readings of wood floor framing members in basements or crawl spaces and discussion with residents when available. Assessments were conducted on nine homes, one of which was unoccupied. The unoccupied home had been vacant for several weeks.

Day 4: Wednesday, December 4, 2002

On Wednesday, four additional homes were inspected at the Bad River Reservation. Inspections were performed by two inspection teams. The attached *Technical Housing Assessment Report* provides a detailed analysis of findings and recommendations for the homes investigated at the Bad River Reservation.

On Wednesday afternoon a meeting was held at the Bad River Housing Authority to discuss the initial findings from the housing inspections. In attendance were the participants from the BRC, Magna Systems, HUD, and IHS. Mary Maday, Donald Neveaux and Bruce Ford from the Housing Authority staff, and Mary Bigboy from Bad River Health Services also attended. Some of the preliminary findings relating to mold and moisture problems and potential causes for those problems were discussed. Mr. Neveaux and Mr. Ford presented construction documents for the new housing construction underway at the reservation. These documents were reviewed for drainage and overall moisture control.

FINDINGS

An overview of findings and recommendations for the Bad River site visit follows.

Bad River Reservation

1. Site drainage was poor at several homes. Grade adjacent to the homes was flat. Numerous holes and dips were found around the perimeter of the homes. Crawl space vents were near grade. Efforts are needed to divert rain water/snow melt away from the house foundations.

2. Several of the homes had no gutters or down spouts, and those that did frequently had broken or missing downspouts. Drip lines were visible around the perimeter of the house. The lack of a rainwater management system compounds the poor site drainage problem. The installation of gutters, downspouts, leaders and splashblocks to drain water away from the house would help with the site drainage problems. Having this water away from the house reduces the negative impact that the current site drainage has on wet foundations.

3. Crawl spaces were a problem with respect to site drainage, clutter and ductwork. The installation of gutters, downspouts, leaders and splashblocks near the crawl space would eliminate moisture in the crawl space from drainage problems. Keeping clutter out of the crawl space and using insulation and proper ductwork would eliminate other moisture problems.

4. Improperly vented bathroom and kitchen exhaust fans contribute to mold growth on roof sheathing. Large amounts of moisture can be generated in bathrooms and kitchens given their function. Properly operating exhaust fans are key to removing moisture from these spaces and lowering the moisture load in the houses.

5. A number of maintenance issues contribute to moisture and other indoor air quality issues. These maintenance issues include leaky and disconnected ductwork, sump pumps, attic hatches and attic insulation.

6. Occupant lifestyles also contribute to moisture and other indoor air quality issues. Lifestyle issues include clutter in crawl spaces and basements and dust accumulation on window sashes, which along with moisture provide a medium for mold growth and firewood stored in basements. Occupant cooperation is essential to minimize moisture and other indoor air quality problems.

PROGRAMMATIC RECOMMENDATIONS

A formidable challenge to all housing authorities is the development of a service-delivery system that effectively addresses mold and moisture conditions promptly. This requires a partnership between the housing authority and occupants. A system could include training for the maintenance staff on how to implement the technical recommendations, and training for residents on their roles and responsibilities as renters and homeowners. In many cases, moisture problems develop but go unreported and unrepaired, allowing significant mold contamination that could have been avoided. Some strategies to meet these challenges follow:

1. As part of the annual recertification process, require occupants to attend annual homeowner/renter clinics. These clinics would provide instruction on home maintenance issues. Topics such as identifying and repairing leaks and gutter maintenance could be presented.

2. During the annual recertification process, ask occupants to fill-out a survey based on Housing Quality Standards (HQS), which includes additional questions on mold and moisture conditions in their homes. By having the resident complete a survey it engages them in their own home maintenance. The survey responses also provide additional information to the Housing Authority on any unreported problems (especially leaks and inoperable fans) that may contribute to an unsafe and unhealthy home environment.

TECHNICAL HOUSING ASSESSMENT REPORT

EXAMINING MOLD AND MOISTURE CONDITIONS OF HOMES ON THE BAD RIVER RESERVATION

EXECUTIVE SUMMARY

Fifteen homes on the Bad River reservation were inspected for mold and moisture problems. Mold, water, and moisture problems were found in several homes. Our principal findings include:

1. Numerous holes and dips were found around the perimeter of the homes. Crawl space vents were at or near grade.

2. Several of the homes had no gutters or down spouts and those that did frequently had broken or missing downspouts. Drip lines were visible around the perimeter of the house. The lack of a rainwater management system compounds the poor site drainage problem.

3. Crawl spaces had problems related to site drainage, clutter and ductwork.

4. Improperly vented bathroom and kitchen exhaust fans contributed to mold growth on roof sheathing.

5. Maintenance issues, such as leaky and disconnected ductwork, sump pumps, attic hatches and attic insulation contributed to moisture and other indoor air quality issues.

6. Occupant lifestyles also contributed to moisture and other indoor air quality issues. Lifestyle issues include clutter in crawl spaces and basements and dust accumulation on window sashes, which along with moisture provide a medium for mold growth and firewood stored in basements.

This report provides technical recommendations and discussions focusing on these items. Appendix A provides a summary of findings at each inspected home. Appendix B includes a detailed assessment of each home.

INTRODUCTION

The Assessment Team responded to a request from the Eastern/Woodlands Office of Native American Programs to assess site and building structural conditions contributing to mold and moisture problems on the Bad River Reservation. The investigation was conducted on December 3 – 4, 2002, by Bill Rose and Jeff Gordon, BRC staff, and Robert Nemeth, Magna Systems staff; Diana Kuklinski, Acting Divison Director Bemidsi Environmental Health Services; Casey Crump, Rhinelander District Environmental Health Officer; and Dick Reese, Environmental Health Officer from North American Health Alliance; and Hal Beiler, from HUD. Two members of the Housing Authority maintenance staff escorted the inspection teams. This group was divided into two teams to minimize the imposition into each property and maximize the number of properties visited. The Housing Authority pre-selected the houses.

The Bad River Reservation is located in northern Wisconsin where the winter climate consists of cold temperatures and heavy snowfall. The region has many lakes, streams, and rivers along with wetlands and marshes. Tribal staff reported high water tables. This type of topography could contribute to mold and moisture conditions.

SECTION 1 - METHODOLOGY

Visual inspection was primarily used to assess mold and moisture conditions in the homes. Framing moisture content was measured with a moisture meter in basements and crawl spaces where moisture levels were believed to be elevated.

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 Table 1 of Appendix A in this report. The findings from each individual house inspection are presented in Appendix B.

Visual Inspection

Housing inspections consisted primarily of visual assessment of mold and moisture conditions. Assessment forms developed for the Chicago Mold and Moisture Project (a HUD Healthy Homes Program) were used to record information. 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, basements, crawl spaces, utility rooms and attics included additional inspection relating to plumbing, localized ventilation, water entry and other moisture source issues.

The exteriors of the homes were inspected for rain water/snow melt management, including site grading, roof condition and gutter system.

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

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

Measurements

In basements and crawl spaces where elevated moisture levels were suspected, moisture content measurements were taken of floor framing members. Because of the storage capacity of wood, moisture content measurements provide information on foundation and basement/crawl space wetness in the recent past, from three weeks to a month. Moisture content readings can range from 5%, a very dry reading, to 30%, a very wet reading.

SECTION 2 - FINDINGS

2.1 Site Drainage

Site drainage was poor at several of the inspected homes. Site drainage was either flat or pitched towards the foundation. Four of the fifteen homes had basements, three of which exhibited signs of water entry into the basement. Six homes had crawl spaces, three of which showed signs of water entry.

2.2 Rainwater/Snow Melt Management

Rainwater/snow melt management was poor in seven of the inspected homes. Five of the homes had roof drainage systems (gutters, downspouts and leaders). However, in many instances, the drainage system had been compromised, and in several cases, exacerbated moisture problems by funneling runoff onto wall surfaces. Drips lines were visible around the perimeter of several inspected homes.

2.3 Crawl Space Design

A number of problems were found in several of the crawl spaces in addition to the site drainage issues discussed above.

Thermal Boundary

The thermal boundary is the building assembly that separates conditioned space from outside conditions. Crawlspace walls were insulated with one to two inches of extruded polystyrene foam (R5 to R10) on the exterior of the block walls up to grade. The block was exposed above grade. This indicates the foundation walls are the thermal boundary; however, the crawl spaces were vented (analogous to opening a window in a heated room). If the crawl spaces are to be vented, then the floors above the crawl spaces should be insulated and air sealed with all mechanicals (ductwork, plumbing) above the insulation. The mechanicals are currently exposed in the crawl spaces.

Ground Covers

The floor of the crawl space is covered with sand. Displacement of this mixture exposed a polyethylene ground cover. However, it could not be determined if the ground cover is continuous without voids or gaps. A continuous ground cover prevents ground water from moving up into the crawl space.

Ductwork/Plumbing

Ductwork and plumbing for the home is contained within the crawl spaces. The main trunk line is insulated; however, the branch lines are not insulated. Although not a moisture issue, energy is being lost to the vented crawl space, particularly since there are two supply air registers located in the crawl space. Uninsulated plumbing pipes could lead to frozen pipes.

2.4 Bathroom and Kitchen Exhaust Fans

All of the bathrooms had exhaust fans. Properly operating exhaust fans help remove moisture from the bathroom during showers. Past flow measurements of typical exhaust fans show that they frequently only exhaust 25 to 50 percent of their CFM rating. In addition, most of the bathroom fans were quite noisy. Occupants tend not to use fans that are loud. All of the bathroom exhaust fans were supposed to be vented directly to the outside. However, in three instances, the flexible duct connecting the fan to the roof vent was disconnected and the duct was venting into the attic.

In the kitchen there was a mix of recirculating and venting exterior range hoods. The recirculating hoods do not contribute to the elimination of moisture or combustion byproducts from gas stoves.

2.5 Attic Hatches

There was extensive staining on several of the attic hatches (Figure 1). This indicated that the bottom side of the hatch was cold, because of little or no insulation above, resulting in moisture condensing on the hatch surface. While wet, the moisture picks up air-borne pollutants, which then stain the surface when the surface dries. Frequently the attic access hatch is located near a bathroom, which compounds the problem. Warm humid air migrating out of the bathroom contacts this cold surface and causes a wet attic access hatch.

Figure 1 - Stained Attic Access Hatch

Another concern is that the perimeter of most hatches is not airtight when closed. Warm moist air can move up into the attic around the perimeter of the hatch. Although not present, the potential for water condensing on cool surfaces above the hatch could provide moisture for mold growth.

2.6 Maintenance Issues

A number of maintenance issues were found that could lead to mold growth, as well as other indoor air quality (IAQ) issues in the home.

Sump Pumps

Sump pump ejector pipes were extended from the residences in PVC pipe laid directly on the ground. Although easy to visually inspect, this approach leaves the drainage pipe susceptible to damage from children, mowing, pets and other outdoor activities. An additional concern is that if there is standing water in the pipe, freezing could occur and either break the pipe or cause the water to back up into the interior.

Ductwork

Return air ducts were found in the basements and crawl spaces. Leaky return ductwork can lead to mold and other IAQ issues in the home by drawing in pollutants found in these spaces and distributing it throughout the house. A disconnected return air plenum was found at 73245 West Denomie (Figure 2). Conditioned interior air was being deposited directly into the crawl space and crawl space air was being drawn into the return air plenum.

Figure 2 – Return Air Open to Crawl Space

Attic Insulation

All of the inspected attics had a minimum of 12" of insulation covering most of the ceiling. The problem areas were along the perimeter at the heel end of the trusses. Due to the shallow depth of the truss and the installation of baffles to maintain airflow, there was insufficient space for an adequate amount of installation. In addition, the truss itself acted as a thermal bridge where it sat on the wall and further increased the heat loss at this location.

2.7. Occupant Education

Occupant education and cooperation is essential to minimize mold, moisture, and other IAQ problems. A number of occupant items were identified that can cause moisture and mold problems. Occupants should be trained in the following topics to assist them in solving and eliminating moisture and mold problems in their homes.

- What is mold and what causes it
- Use of exhaust fans
- Use of basements and crawl spaces
- Changing furnace filters
- Difference between plumbing leaks and water condensing on pipes
- Use of sump pumps

- Ductwork
- Humidifiers

SECTION 3 – TECHNICAL RECOMMENDATIONS

The following recommendations are based on the site visit findings.

3.1 Site Drainage

Rain water/snow melt must be diverted away from the house foundation. Diversion efforts include:

- Overall site grading to prevent water from flowing toward the houses. Constructing swales and French drains may be helpful in some cases.
- Grading directly at the foundation to ensure a soil pitch away from the foundations.
- Seal crawl space vents on houses where the thermal boundary is the crawl space walls rather than the floor plane.

3.2 Rain Water/Snow Melt Management

Several of the homes had visible drip lines from rain and snowmelt. Water collects around the house perimeter and drains down along the foundation walls due to poor drainage. A good water management plan includes the following:

- Install gutters, downspouts, leaders and splash blocks to drain water away from the house. Moving the water away from the house reduces the negative impact that the current site drainage has on wet foundations. Wisconsin winters and forested building sites can damage and impair gutter systems.
- Routine inspections and cleaning must be instituted. A gutter guard system can help keep debris out of the gutter, thus minimizing maintenance, while allowing water to drain into the gutter.

3.3 Crawl Space Design

The crawl space foundation walls were the thermal boundary in the inspected homes. The foundation walls were insulated below grade and exposed above grade. The thermal boundary was violated by the venting and substantially compromised by the exposed course(s) of block that were not insulated above grade. The crawl space vents allowed cold air to enter the crawl space in the winter causing wasted energy dollars while increasing the potential for freezing pipes. Furthermore, the location of the vents near grade allowed moisture and potential vermin to enter the crawl space. Ductwork and

plumbing were located in the crawl space. The following recommendations would improve the crawl spaces:

- Seal existing crawl space vents to make watertight.
- Install rim joist insulation along the perimeter of the building.
- Clear the crawl spaces of all debris and then cover with a continuous and sealed ground cover such as a concrete slab, polyethylene sheet or other vapor-proof material.

3.4 Bathroom and Kitchen Exhaust Fans

Bathrooms and kitchens generate large amounts of water. Properly operating exhaust fans remove moisture from these spaces. Recommendations regarding bathroom and kitchen exhaust fans include:

- Replace inoperable exhaust fans. New bathroom fans should have sone ratings no higher than 1.5. Low-sone fans include Broan *Solitaire* and Panasonic *WhisperCeiling* and *WhisperLite* series. Low-sone fans generally cost between $75 and $100.
- In some cases, a through the wall exhaust fan may be appropriate. One such fan is the Panasonic *WhisperWall* unit (70 CFM, 1.1 sones).
- Replace existing bathroom light/fan switch with a fan delay timer. The 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 $35.00.
- Inspect all bathroom and kitchen exhaust fan ducts. Ensure that exhaust ducts are properly attached and sealed to the exhaust fan housing. All ducts should terminate outside the house and not below roof vents.
- If exhaust venting is taken through the roof eaves, ensure that the ducts terminate and are sealed to a properly design eave vent designed for exhaust fan termination and pointed away from soffit vents.
- Inspect dryer vents to assure that they are vented to the outside.

3.5 Air Seal Attic Hatches

Most of the attic hatches had water condensation stains on them. Though most of the inspected hatches were insulated, they were not air sealed allowing warm moist air to

move into the attic around the perimeter of the hatch. Improvements to attic hatches include the following:

- Install air seal attic hatches with positive closure. Foam weather-stripping can be installed along the perimeter of hatch stop. Sash locks, gate hooks or another type of latch can be used to provide positive closure of hatch-to-hatch stops.
- Cut rigid insulation to the same size of the hatch door and glue or fasten the insulation to the top of the hatch. Three layers of one-inch thick polyisocyanurate would provide an insulation level of approximately R-30. Trying to adjust batt insulation to cover the hatch as it is closed rarely provides adequate insulation above the hatch.

3.6 Maintenance Items

The assessment team identified number of maintenance items regarding moisture and other IAQ problems.

- Besides general site drainage problems, a number of holes and dips were found adjacent to foundations that should be filled-in even if site drainage work is not planned.
- Remove clutter from crawl spaces. Remove all debris following repair work in a crawl space.
- Inspect attic insulation. Insulation that has been brushed-away from previous attic work should be replaced. There should be no exposed ceiling drywall in the attic.
- Inspect ducts located in crawl spaces. All duct joints should be sealed with duct mastic and all ducts should be insulated. Duct mastics include *RCD Corp. #6*, *Seal-n-Save* by United-McGill and *Permatite 777*. Duct tape should not be used. An acceptable tape is *SF-686* by Shurtape Technologies. Duct register boots that have dropped from the floor should be re-attached.
- Inspect ducts in basements and ensure that all ducts are connected. Duct joints should be sealed with duct mastic.
- Inspect sump pumps for proper operation. Connect a discharge pipe with back-splash on exterior of home.
- Repair plumbing leaks in a timely fashion. Remove scrap material and clean mold, if present.

3.7 Occupant Education

Occupant cooperation is essential to minimize moisture and other IAQ problems.

- Instruct occupants on importance of using bathroom and kitchen exhaust fans during and after bathing and cooking activities to remove moisture from these spaces.

- Inform occupants not to use crawl spaces for storage or as a receptacle for garbage. In basements keep boxes on raised platforms and away from basement walls.

- Firewood should not be stored in basements.

- Discourage the use of rugs in basements. If rugs are used in basements, the occupant should inspect the underside of the rugs periodically for the presence of mold. Discard rugs with mold.

- Discourage putting mattresses directly on basement floors. Raise mattresses off of the floor to allow air circulation.

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

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

- Promptly report disconnected ducts.

- Instruct occupants on proper use of sump pumps and that water should not be visible in the well.

SECTION 4 – DISCUSSION OF COMMON PROBLEMS

The inspection of housing at Bad River identified a number of problems that are discussed in further detailed in this section.

4.1 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, across the site, and off the property. The houses that allow water to accumulate in the soil next to the foundation have problems. 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 next to the foundation dry.

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 properly. The worst damage occurs 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. Imagine all the water moving to the low edge of the site, and imagine how best to get it there. Avoid areas near the building that can act as water collectors. Specific site drainage guidelines include:

- The house should be built on a crown, not in a hole. If there is sufficient exposed foundation, site grading at the house can be improved. If the house 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 house has no gutters, then the base of the soil around the house serves as a gutter. It should have a surface that helps prevent splash back onto the siding of the house. It should be designed with a pitch that 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.

4.2 Rain Water/Snow Melt Management

Rain water and snow melt from the roof should be collected and distributed away from the foundation with a gutter system. Flashings around chimneys and vents should be watertight.

- Include waterproofing underlayment at the eaves and in valleys as part of re-roofing to help prevent water damage caused by ice dams.

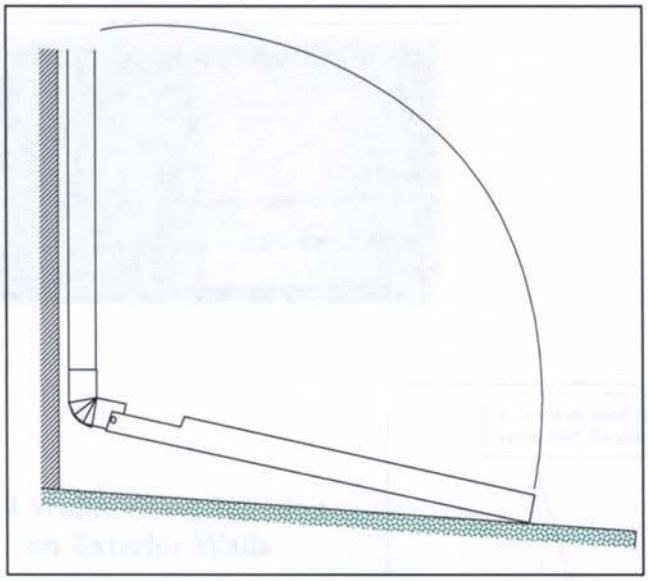

Figure 3: To deposit downspout water well away from the foundation, consider using a hinged extender. It can pivot up and out of the way when the lawn is being mowed.

- Gutters can be an effective rain water/snow management system. Pitch the gutters to the downspout. Short gutters may be hung level. In hip roof houses, consider using downspouts only on the downhill side, not on the uphill side. In areas with a moderate amount of trees, consider large gutters and downspouts so that leaves and debris can be flushed more easily. Make sure the gutter hangers are solid to prevent the gutters from sagging.
- Downspouts should be secured to the house. They should never be undersized, and some oversizing never hurts. Fasten elbows and straight sections together with pop rivets. Screws that project into the downspout can lead to clogging.
- At the base of the downspout direct water away from the foundation of the building and out past the backfill onto the undisturbed soil, which may be 3' to 5' out from the edge of the house. If water drains close to the foundation, into the backfill, the water will concentrate next to the foundation—precisely the wrong place for the water to be. The traditional way to discharge the water away from the house involves using downspout extenders (sections of straight downspout) or splash blocks. Both of these are often disturbed when lawns get mowed. Instead, use a notched section of downspout that is hinged to the elbow at the base of the downspout (Figure 3). The soil at the base of the downspout should be sloped away from the house at a minimum of 5% slope. Six inches of fall in the first 10' away from the house gives a 5% slope.

- Keep cutters clean particularly in wooded areas. A gutter guard system can help keep debris out of the gutter, thus minimizing maintenance, while allowing water to drain into the gutter.

Two such gutter guard systems are the *PermFlow Gutter Guard System* Figure 4and the *WaterFall Gutter Guard System* (Figure 5). These systems cost about $4.50 per 3' section and are designed for a 5" K style gutter (8' sections are sold to contractors).

Figure 4. PermFlow Gutter Guard

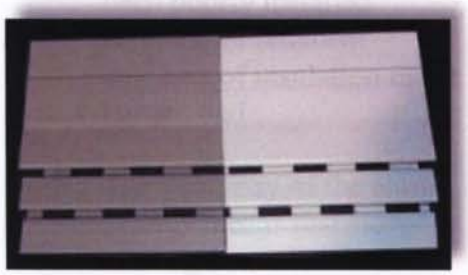

Figure 5. Waterfall Gutter Guard System

4.3 Wall/Ceiling Junction on Exterior Walls

Several inspected houses showed signs of condensation and staining at the wall/ceiling junction along the north elevation. Staining rather than mold growth was apparent at one site, but the source of the staining was not identified. This is a very common problem in northern climates, especially in older ranch-style homes with low-pitched roofs.

High relative humidity and cold surfaces can lead to mold growth. If a surface approaches the dew point temperature based on the

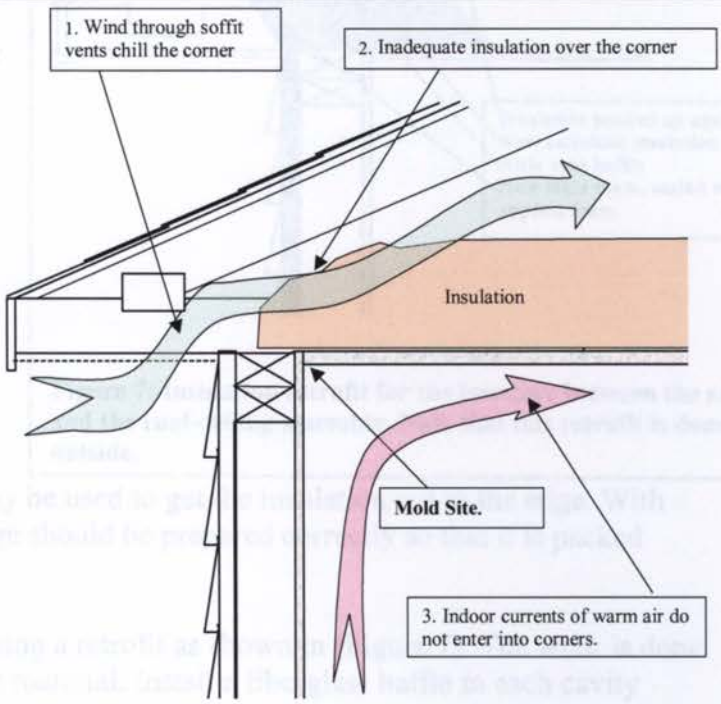

Figure 6: Wall-ceiling corners are cold because of (1.) Wind movement through soffit vents, (2.) Smaller amounts of insulation at the corner, and (3.) Corner is outside the movement of warm air currents indoors.

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 in the corner, and

3. The geometry of the corner usually means that slow-moving currents of warm air may not be able to reach into the corners (Figure 6).

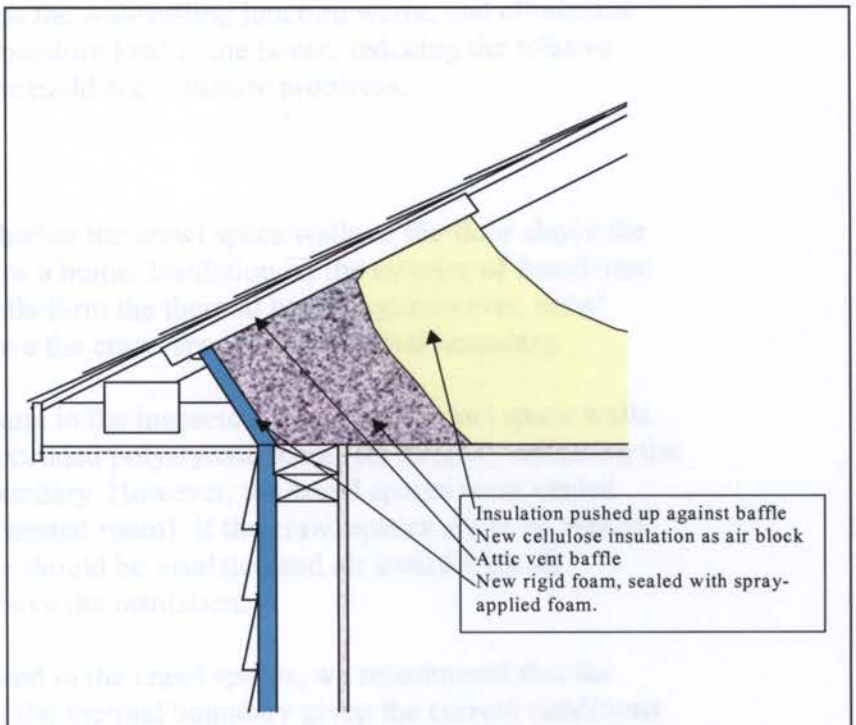

Figure 7: Insulation retrofit for the juncture between the exterior wall and the roof-ceiling assembly. Note that this retrofit is done from the outside.

Dark spots occur where the interior surfaces are the coldest. They occur there because that is the hardest place to insulate effectively. In new construction, use a raised-heel truss and make sure the insulation installer pays special attention to the wall-roof joint. 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.

In existing construction consider using a retrofit as shown in (Figure 7). The work is done from the outside. Remove the soffit material. Install a fiberglass baffle in each cavity space. Push the existing insulation back up against the sheathing or the baffle. Blow in new cellulose insulation, or pack in fiberglass insulation, into the cavity. Then install pre-cut rectangles of rigid foam insulation to block air flow. (If blowing in loose-fill insulation, the rigid foam insulation should be installed first, and blown insulation second). Use spray-applied foam insulation to keep the rigid rectangle in place. Replace the soffit. If the attic is ventilated, make sure that nothing blocks the baffles.

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 major drawback. Designs without attic ventilation may improve the performance of the eave area. 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 "Issues Related to the Venting of Attics and Cathedral Ceilings" http://www.fpl.fs.fed.us/documnts/pdf1999/tenwo99a.pdf.

The retrofit presented in Figure 7 keeps the wall/ceiling juncture warm, and eliminates the condensation site. Lowering the moisture load in the house, reducing the relative humidity also helps prevent wintertime mold and moisture problems.

4.4 Crawl Space Design

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 exterior of foundation walls indicates that the foundation walls form the thermal boundary; however, crawl space vents indicate that the floor above the crawl space is the thermal boundary.

Both of the above conditions were found in the inspected homes. The crawl space walls were insulated with one to two inch extruded polystyrene foam (R5 to R10) indicating the foundation walls form the thermal boundary. However, the crawl spaces were vented (analogous to opening a window in a heated room). If the crawl spaces are to be vented, then the floors above the crawl spaces should be insulated and air sealed with all mechanicals (ductwork, plumbing) above the insulation.

If the mechanicals are currently exposed in the crawl spaces, we recommend that the crawl space foundation walls serve as the thermal boundary given the current conditions found in the homes.

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

- Crawl spaces should have easy access and good lighting so as to enable regular inspections.
- Water in crawl spaces typically comes from poor rainwater management outdoors, groundwater, or plumbing leaks.
- Cover the ground surface with a ground material: a slab of concrete, 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. The ground cover must also be sealed to foundation piers interior to the crawl space.

4.5 Localized Exhaust Ventilation

Bathrooms, kitchens and utility rooms are typical 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. Forced ventilation exhausts 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.

Bathroom fans should exhaust between 50 Cubic Feet per Minute (CFM) and 70 CFM. 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.

5. Air Seal Attic Hatches

Warm air rises during the winter due to the stack effect. Any penetration through the ceiling that is not air sealed will allow the air to pass through it. Moisture carried with the air can condense on cold attic surfaces. Although the attic hatches were insulated, the perimeter of the hatches were not air sealed.

The hatches should be air sealed as shown in Figure 8. Latches should be installed to lock the hatches in place and provide positive closure.

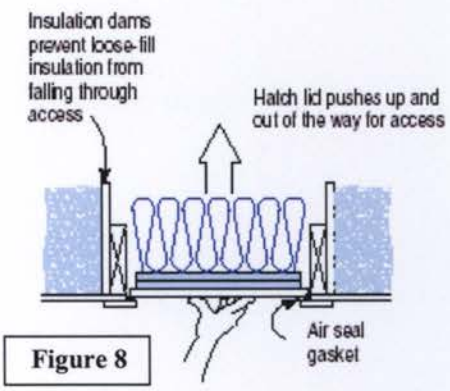

Figure 8

6. Maintenance Items

Many moisture problems, and consequent mold contamination, result from deferred maintenance. Address water leaks promptly. If water infiltration problems from

plumbing, roofing, or foundation sources linger, a small problem can turn into a large problem, consequently the potential for mold can turn into a major contamination site. Unfortunately water leakages often go unreported and unattended.

A Housing Authority's best defense against mold and moisture complaints is its maintenance department. A good proactive maintenance program guards against mold and moisture problems by including the following procedures:

- Perform regular inspections of properties to identify problem moisture conditions
- Encourage reporting of moisture problems from residents
- Respond promptly to identified and reported moisture problems to prevent excessive mold contamination

Deferred maintenance items can cause moisture and mold problems. Maintenance staff should be trained in the following items to assist in solving and eliminating moisture and mold problems.

General

- what is mold
- what causes mold
- other IAQ problems
- sources of moisture
- moisture assessment procedures

Exterior

- site drainage
- site drainage on homes without gutters
- paving adjacent to homes
- plantings around home

Foundations

- thermal boundary
- crawl space design issues
- sump pumps
- clutter
- rugs in basements

Attics

- attic bypasses
- attic hatches

- attic ventilation
- ice dams
- insulation
- wall/ceiling junctures

Mechanical

- bathroom and kitchen exhaust fans
- venting exhaust fans to the exterior
- plumbing leaks
- ductwork
- humidifiers
- unvented appliances

Mold Remediation

- clean-up
- when to call for outside help

7. Occupant Items

A number of occupant issues can cause moisture and mold problems. Occupants should receive training on the following topics to assist in solving and eliminating moisture and mold problems in their homes.

- what is mold and what causes it
- use of exhaust fans
- use of basements and crawl spaces
- changing furnace filters
- difference between plumbing leaks and water condensing on pipes
- use of sump pumps
- ductwork
- humidifiers

Appendix A

Bad River Summary Table of Home Assessments

December 1-6, 2002

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Inspection Number	**Address**	**Building Age (Years)**	**Occupancy**	**Model Type**	**Foundation Type**	**Framing Type**	**Heat Type**	**Basement framing moisture content**	**Site Drainage Problems**	**Gutter System Problems**	**Leaks From Exterior**	**Wet Basement or Crawl Space**	**Plumbing Problems**	**Bathroom Problems**	**Exhaust Ventilation**	**Exterior wall/ceiling problems**	**Attic Problems**	**Visible Mold**
1-1	73243 West Denomie Street	6	2	Frame Ranch	Block Crawl Space	Frame	Natural gas forced air	NA	Yes	No Gutters	No	Inaccessible space	No	No	No	Yes	Yes	17,18
1-2	73356 Lemiena	Not established	Unavailable	Frame Ranch	Block Crawl Space	Frame	Natural gas forced air	20%	Yes	No Gutters	No	Yes	No	No	HRV	Yes	No	13
1-3	75602 Mocassin Drive	9	5	Wood Frame Ranch	Block Basement	Frame	Natural gas forced air	NA	Yes	No Gutters	No	Yes	No	No	HRV	No	Not Accessible	13
1-4	75578 Mocassin Drive	10	4	Frame Ranch	Block Basement	Frame	Natural gas forced air	NA	Yes	No Gutters	No	Yes	No	No	HRV	No	No	13
1-5	75768 Mocassin Drive	10	5	Frame Ranch	Block Basement	Frame	Natural gas forced air	NA	Yes	No Gutters	No	Yes	No	No	HRV	No	No	No
1-6	73235 West Denomie Street	7	3	Duplex - Ranch	Concrete block crawl space	Light frame w/ roof trusses	Natural gas forced air	8-9%	Potential in heavy rains	No Gutters	Thru crawl space vents	Damp	No	Yes	Yes, but doesn't draw	Yes	Minor	15,17,18
1-7	60-02 Maple Street	30+	Unavailable	Bi-Level	Concrete Block	Light frame w/ roof trusses	Natural gas forced air	N.A.	Some	yes	No	No	yes	Yes	Yes	Yes	No	15,17
1-8	54227 Kinnik Kinnik Road	30+	Vacant	Bi-Level	Concrete Block	Light frame w/ roof trusses	Natural gas forced air	N.A.	Yes	yes	yes	yes	No	Yes	Yes	Yes	Not Inspected	15
1-9	77847 Red Pine Road	18	Unavailable	Ranch	Concrete block crawl space	Light frame w/ roof trusses	Natural gas forced air	6% joists 20% band joist	No	yes	No	No	No	Yes	HRVC	Yes	Not Inspected	15,17
2-1	58817 Circle Drive	30+	5	Ranch	Slab on Grade	Light frame w/ roof trusses	HW Baseboard	N.A.	Yes	No Gutters	No	NA	No	Yes	Yes	No	Yes	None
2-2	54238 Kinnik Kinnic Road	20	Unavailable	Bi-Level	CIP Concrete	Light frame w/ roof trusses	Natural gas forced air	N.A.	Yes	yes	No	Yes	Yes	Yes	No	Yes	Yes	13,15
2-3	Box 378E RR2	30+	1	Ranch	Block Basement	Light frame w/ roof trusses	Natural gas forced air	N.A.	No	No Gutters	No	No	No	Yes	Yes	Yes	No	15,17
2-4	77850 Firebreak Road	22	7	Ranch	Block Crawl Space	Light frame w/ roof trusses	Natural gas forced air	6% -9%	No	Partial Gutters	No	No	No	Yes	Yes	No	Not Inspected	15
2-5	not known	30+	Unavailable	Ranch	Concrete block crawl space	2x4 Wood Frame	Natural gas forced air	N.A.	Yes	No Gutters	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
2-6	not known	unknown	5	Ranch	Concrete block crawl space	2x4 Wood Frame	Natural gas forced air	6-9%	No	Partial Gutters	No	Yes	No	No	Yes	Yes	No	Yes

Inspection Number: 1-1
Address: 73243 W. Denomie St. East apartment
Model Type: Frame Ranch Duplex
Age: 6 years old
Bedrooms: 2
Foundation: Concrete block crawl space
Heat Type: Gas forced air
Construction: Wood framed
Attic: Fiberglass batt insulation

Figure 1: 73243 W. Denomie St.

Mold and Moisture Conditions: The east apartment in this duplex was suffering from a high moisture load, presumably from an elevated moisture source in the crawl space. Condensation and mold contamination was evident at exterior wall/ceiling junctures and ceilings. Excessive condensation occurred at the windows.

Figure 2: Crawl space vent

Rainwater Management: The site was relatively flat. There was no roof drainage system (gutters, downspouts, etc.). The house was built very low to the ground, to the extent that there was insufficient foundation height for installing crawl space vents in the concrete block area. Instead, crawl space vents were installed in the band joist (Figure 2). Often the combination of a flat site and missing roof drainage in a house built so low to grade will lead to foundation wetness.

Figure 3: Mold growth at exterior wall/ceiling juncture

Crawl Space Conditions: The duplex was built on a concrete block crawl space. Because of a cabinet placed over the access hatch, the crawl space was not accessible for inspection. Because no other sources for the excessive interior moisture load were identified, experience suggested that the apartment was on a wet crawl space. The crawl space should be accessed and examined for foundation wetness. Inspection of the crawl space below the west apartment of the

duplex indicated some moisture, but not severe foundation wetness. That fact, however, did not eliminate the possibility of excessive wetness below the separated foundation on the east apartment.

Exterior Wall/Ceiling Junction: There were indications of condensation events at the wall to ceiling junction along the north elevation. The condensation appeared chronic, and has led to mold growth in numerous locations in the house (Figures 3 & 4).

Figure 4: Mold growth at exterior wall/ceiling juncture

Window Condensation and Damage: Extensive condensation occurred on all the windows throughout the apartment. The windows were not detailed with wood trim, but rather with drywall returns. Drywall is notoriously intolerant of elevated moisture conditions. Due to heavy condensation, mold growth and water damage was evidenced at most of the window openings (Figures 5 & 6).

Figure 5: Window condensation, mold, and moisture damage

Figure 6: Window condensation, mold, and moisture damage

Bathroom: There were no mold or moisture problems identified in the bathroom.

The bathroom exhaust fan was operated by a humidistat that was set at over 80% relative humidity (CRH). When the control was turned down, the fan was activated at around 70% relative humidity, a good indication of the high moisture load in the house. A subsequent measurement of interior relative humidity indicated 63% RH. That level of moisture load in the climate of northern Michigan was sure to lead to the condensation problems noted.

Attic Conditions: Storage of personal belongings restricted access to the attic. The attic was generally dry. Some condensation was noted in the vicinity of a plumbing stack (Figure 7). While there was sufficient fiberglass batt insulation in the attic, some mold contamination on the ceilings of the apartment indicated that there might be places with poor insulation coverage. There was mold growth on the attic hatch cover resulting from insufficient insulation of the hatch cover (Figure 8).

Figure 7: Condensation at plumbing stack

Occupant Information: There were two occupants in the apartment, neither of them smokers. There was no evidence of occupant behavior that would result in the excessive moisture load in the house. One occupant suffered from lupus, and also reported having sinus and ear infections.

Figure 8: Mold growth on attic hatch

Recommendations: The excessive moisture load in the house must be reduced.

1. The crawl space should be accessed to determine the contribution of moisture from the foundation to the house. Exterior drainage, gutters, etc. should be considered to address foundation moisture. See Section 4.2.
2. Windows details, allowing for trimming the windows with more maintainable wood trim rather than drywall, should be installed on trouble windows.
3. Mold should be cleaned up according to New York City (NYC) and Environmental Protection Association (EPA) guidelines. See Section 6.
4. The attic hatch should be cleaned and insulated to prevent localized condensation and mold contamination.
5. Increase the surface temperature at the wall/ceiling juncture, thus preventing cold spots for condensation and mold contamination, should be followed. See Section 4.3.

Inspection Number: 1-2
Address: 73356 Lemieux Rd.
Model Type: Frame Ranch
Age: Not established
Bedrooms: 3
Foundation: Concrete block crawl space
Heat Type: Gas forced air
Construction: Wood framed
Attic: Truss construction, blown cellulose insulation.

Figure 1: 73356 Lemieux Rd.

Mold and Moisture Conditions: There was evidence of water staining at the wall/ceiling junction at exterior walls. The crawl space was very wet, with extensive, mold growth.

Rainwater Management: Grading at the site was fairly good, with the soil pitched away from the foundation at the minimum recommendation of 6" in the first 10'. There was a roof drainage system (gutters, downspouts, etc.) on both sides of the gable. Leaders from the downspouts could be extended a greater distance away from the foundation (Figure 2). The house was built very low to the ground.

Figure 2: Downspout and leader at rear of house

Crawl Space Conditions: The crawl space was excessively wet, fully saturating a sandy soil. Mold growth was apparent on the ground, lower walls, and on wood debris lying on the soil. A moisture measurement of one piece of wood indicated full saturation of 30% moisture content. Evidence is visible of running water periodically occurring in the crawl space (Figure 3). There was no vapor retarder on the floor. The sump pump was connected to a plastic, interior perimeter drain tile that was exposed in places. This system is obviously insufficient to keep the crawlspace dry. The waste line to the sewer ran at floor level through the crawl space. There was considerable corrosion to the line and signs of possible leaking near the foundation wall (Figure 4).

It should be noted that both supply and return ductwork are run through the crawlspace. Supply air from the HRV is connected to the supply side of the ductwork in the crawl space. Whenever ductwork runs through a contaminated space, there is potential for the system to draw contaminated air into the ductwork and distribute it

Figure 3: Crawl space. Note wood debris and signs of running water.

through the house. This is particularly true of return ductwork, which operates in negative pressure.

Wall/Ceiling Junction on Exterior Walls:
There were signs of water staining in two rooms at the wall/ceiling junction on the west elevation (Figure 5). The stains did not appear to be the result of condensation, and there was no mold growth apparent on the interior surfaces. Based on the appearance, the water staining could have resulted from past ice damming. There were no signs of ice dams at the time of inspection.

Bathroom Conditions: There were no mold or moisture conditions identified in the bathroom. The bathroom had a functioning exhaust fan.

Ventilation: The house was equipped with a Heat Recovery Ventilation (HRV) system. The ventilation system was functioning, with the exhaust (drawing solely from the laundry room) showing strong flow and condensation at the exterior outlet (Figure 6). The supply inlet was plugged with dry grass and debris. In this case, it is likely that the HRV system was placing the house in negative pressure.

Figure 4: Sewer pipe in crawl space, possible leak.

Figure 5: Water staining at wall/ceiling junction.

Figure 6: Exterior ports for HRV system

The kitchen did not have a range hood ventilating to the exterior. With a gas range and oven, kitchen ventilation to the exterior is necessary to adequately address both moisture and other critical indoor air quality issues.

Occupant Issues: Residents were not available at the time of the inspection.

Recommendations:

1. Keep the exterior supply and exhaust ports for the HRV clean.
2. Extend leaders connected to the downspouts to move rainwater at least 6 feet away from the foundation.
3. The crawl space requires considerable improvement. At the very least, a 6 millimeter plastic vapor barrier is required. Crawl space design is discussed in Section 4.4.
4. The ductwork in crawl space should be sealed with web tape and mastic. This is particularly true of the return air ductwork.

Inspection Number: 1-3
Address: 75602 Moccasin Dr.
Model Type: Frame Ranch
Age: 9 years old
Bedrooms: 2
Foundation: Concrete block basement
Heat Type: Sealed combustion gas, forced air
Construction: Wood framed
Attic: Not accessible

Figure 1: 75602 Moccasin Dr.

Mold and Moisture Conditions: Water infiltration was occurring in the basement. There were no other mold or moisture conditions identified in the house.

Rainwater Management: The site was generally flat near the foundation. There was an existing swale on one side elevation that fed into the drainage ditch on the front of the property (Figure 2). There was no roof drainage system (gutters, downspouts, etc.). Discharge from a roof drainage system could be designed to run to daylight at the swale.

Figure 2: Swale leading to front drainage ditch

Basement Conditions: Staining and efflorescence provided clear signs of water entry into the basement (Figure 3). Water entry was occurring on both of the long elevations. There was a slight moldy smell in the basement. An operating sump pump was connected to exterior footing drains. The sump pump was actively operating, as could be seen by the snowmelt at the exterior discharge (Figure 4). This could indicate a high water table even in the winter. Cracks between the basement slab and block wall allow for water entry at the base of the exterior walls. It should be verified that the footing drains are clear, and providing the optimum pressure relief from hydraulic pressure at the foundation. This, along with improvements to the rainwater management system, could help relieve water entry at the foundation.

Figure 3: Staining from basement water entry.

Bathroom Conditions: There were no mold or moisture conditions identified in the bathroom. The bathroom had a functioning exhaust fan.

Ventilation: The house was equipped with a Heat Recovery Ventilation (HRV) system. The ventilation system was functioning, with the exhaust air being pulled from the basement (Figure 5).

Occupant Issues: There were between 4 to 5 occupants living in the house at any given time, two of which were smokers. It was reported that the baby living in the house had minor respiratory problems. There were no other health problems reported.

Figure 4: Outfall from basement sump pump.

Recommendations:

1. Install gutters and downspouts. Ideally, downspouts can be placed on the elevation closest to the existing swale and can discharged into the drain tile that is run to daylight at the swale. Whenever there is an existing grade to move water to daylight away from the foundation, the elimination of leaders at the base of the downspouts removes one of the chronic maintenance problems of roof drainage systems.

2. Ensure that the footing drains are clear and providing the optimum pressure relief from hydraulic pressure at the foundation.

3. Seal cracks between basement slab and concrete block walls.

Figure 5: Heat Recovery Ventilation System

Inspection Number: 1-4
Address: 75578 Moccasin Dr.
Model Type: Frame Ranch
Age: 10 years old
Bedrooms: 3
Foundation: Concrete block basement
Heat Type: Sealed combustion gas, forced air
Construction: Wood framed

Figure 1: 75578 Moccasin Dr.

Mold and Moisture Conditions: Water infiltration was occurring in the basement. There were no other mold or moisture conditions identified in the house.

Rainwater Management: The site was generally flat near the foundation. There was a drainage ditch on the front of the property that provided a good slope away from the house. There was no roof drainage system (gutters, downspouts, etc.). Discharge from a roof drainage system could be designed to run to daylight at the drainage ditch in an underground tile.

Figure 2: Wet foundation on the west foundation wall.

Basement Conditions: Staining and efflorescence provided clear signs of water entry into the basement. The west wall was wet at the time of inspection (Figure 2). There was a slight moldy smell in the basement. The basement was cluttered with the stored personal items and furniture. In a basement with moisture problems, excessive clutter, particularly of fabrics and paper, make an ideal location for mold contamination (Figure 3). An operating sump pump was connected to exterior footing drains. The sump pump was actively operating, discharging water through a long extension pipe about 20 feet behind the house. The fact that the sump pump was operating in the winter indicated a high water table. Cracks

Figure 3: Basement clutter provides prime mold contamination sites.

between the basement slab and block wall allowed for water entry at the base of the exterior walls (Figure 4). It should be verified that the footing drains were clear and provided the optimum pressure relief from hydraulic pressure at the foundation. This, along with improvements to the rainwater management system, could help relieve water entry at the foundation. A dehumidifier was operating in the basement. It was reported that the dehumidifier was fairly effective at reducing the moisture in the basement.

Figure 4: Crack between basement slab and foundation wall.

Bathroom Conditions: There were no mold or moisture conditions identified in the bathroom. The bathroom had a functioning exhaust fan.

Ventilation: The house was equipped with a Heat Recovery Ventilation (HRV) system. The ventilation system was functioning, with the exhaust air being pulled from the basement.

Occupant Issues: There were 4 smokers occupying the house. It was reported that the grandmother living in the residence had suffered a stroke. There were no other health problems reported.

Recommendations:

1. Install gutters and downspouts. Ideally, downspouts can be connected to drain tile that would carry the rainwater to daylight at the front drainage ditch. Whenever there is an existing grade to move water to daylight away from the foundation, the elimination of leaders at the base of the downspouts removes one of the chronic maintenance problems of roof drainage systems.
2. Ensure that the footing drains are clear and providing the optimum pressure relief from hydraulic pressure at the foundation.
3. Seal cracks between basement slab and concrete block walls.
4. Avoid clutter in basement, particularly fabrics, paper, and cardboard.

Inspection Number: 1-5
Address: 75768 Moccasin Dr.
Model Type: Frame Ranch
Age: 10 years old
Bedrooms: 3
Foundation: Concrete block basement
Heat Type: Sealed combustion gas, forced air
Construction: Wood framed

The house was similar to the other residences inspected on Moccasin Dr, Inspection Numbers 1-3 and 1-4. Due to time constraints, the inspection was limited to an examination of the basement conditions.

Figure 1: 75768 Moccasin Dr.

Mold and Moisture Conditions:
Water infiltration occurred on two elevations in the basement. There were no other mold or moisture conditions identified in the house.

Rainwater Management: The site was generally flat near the foundation. At a gable end elevation there was a hillside that provided good slope away from the house. There was no roof drainage system (gutters, downspouts, etc.). Discharge from a roof drainage system could be designed to run to daylight at the hillside in an underground tile (Figure 2).

Figure 2: Hillside location, possible outlet for roof drainage system.

Basement Conditions:
Staining and efflorescence provided signs of water entry into the basement. An operating sump pump was connected to exterior footing drains. The fact that the sump pump was operating in the winter indicated a high water table. Cracks between the basement slab and block wall allow for water entry at the base of the exterior walls. It should be verified that the footing drains were clear and provided the optimum pressure relief from hydraulic pressure at the foundation. This, along with improvements to rainwater management, could help relieve water entry at the foundation.

Ventilation: The house was equipped with a Heat Recovery Ventilation (HRV) system. The ventilation system was functioning with the exhaust air being pulled from the basement.

Occupant Issues: There were 5 occupants living in the house, two of which were smokers, but no health problems were reported.

Recommendations:

1. Install gutters and downspouts. Ideally, downspouts can be connected to drain tile that would carry the rainwater to daylight at the adjoining hillside. Whenever there is an existing grade to move water to daylight away from the foundation, the elimination of leaders at the base of the downspouts removes one of the chronic maintenance problems of roof drainage systems.

2. Ensure that the footing drains are clear, and providing the optimum pressure relief from hydraulic pressure at the foundation.

3. Seal cracks between basement slab and concrete block walls.

4. Connect the clothes dryer vent to the exterior.

Inspection Number: 1-6
Address: 73235 W. Denomie St.
Model Type: Frame Ranch
Age: Approx. 7 years old
Bedrooms: 2
Foundation: Concrete Block Crawl Space
Heat Type: Direct vent gas forced air
Construction: 2x4 wood frame
Attic: Fiberglass Insulation

Mold and Moisture Conditions: There was evidence of mold above the tub/shower surround (Figure 1), behind the toilet tank, on a window that had condensation on it and in one closet on the exterior wall.

Figure 1 - Area above Bathtub

Rainwater Management: The site was relatively flat and there was no roof drainage system (gutters, downspouts, etc.). The front (entry) side of the duplex had a large (approx. four foot) overhang, which helped keep water away from the structure. The rear of the building had a standard 16 inch overhang.

Crawl Space Conditions: Crawl space access was from a hatch in the mechanical room. The base of the crawl space was sand over a vapor barrier, which appeared to be compromised in several locations. The space was damp but not visibly wet. A water line on the crawl space block walls approximately 8 to 10 inches above the floor level provided evidence of past flooding (Figure 2). No mold appeared to be growing on the block walls. The floor framing moisture content was 8 to 9 percent.

Figure 2 - Water Line on Block Walls

Two heating registers were located in the crawl space, both of which were located proximate to crawl space vents open to the exterior (Figure 3).

The return air register was centrally located in a hallway drawing air into a plenum between two joist spaces. However, sheet metal separating the return air plenum from the crawl space had come loose from the joists (Figure 4) so that return air was dumping directly into the crawl space. The crawl space also had a working sump pump.

Figure 3 - Heating Register Proximate to Crawl Space Vent

Bathroom: Mold was above the tub surround and behind the toilet tank. Occupants allowed the bath fan to run for long periods of time, but that did not seem to help, since the fan did not appear to move air. The fan exhaust terminated in the soffit in what appeared to be a heating register, which was in the closed position.

Attic: The majority of the underside of the sheathing appeared to be in good condition, except above the bathroom there appeared to be some condensation/frost at the upper end of the polystyrene Proper vent baffles (Figure 5). It would be fair to assume that if the bath exhaust register in the exterior soffit were fully open, this condensation/frost problem on the underside of the sheathing would be worse. As the bath fan's moist air was being exhausted on the underside of the soffit, it was being drawn into the soffit vents and was then immediately condensing on the cold underside of the roof sheathing.

Occupant Issues: There were four occupants in the house. One of the occupants was a smoker but stepped outside to smoke. There were no reported health or respiratory problems.

Discussion / Recommendations:

1. Abandon the bath soffit vent and install a new roof vent to exhaust the bath fan.

2. Close and seal crawl space vents to the exterior for the winter months. Currently these vents allow very cold air into the crawl space causing cold spots in the floor above and unnecessary heating costs to residents.

3. Fix the return air plenum in the crawl space.

Figure 4 - Open Return Air Plenum

Figure 5 - Frost on Roof Sheathing

Inspection Number: 1-7
Address: 60-02 Maple Street.
Model Type: Frame Split-Level
Age: Approx. 30 years old
Bedrooms: 4
Foundation: Concrete block stem wall
Heat Type: Direct vent gas forced air
Construction: 2x4 wood frame
Attic: Fiberglass Insulation

Mold and Moisture Conditions: There was mold at the lower level exterior corners (Figure 1), both at the drywall/furring/block elevation (sub-grade) and above grade at the drywall/frame assembly. There was also evidence of mold on the ceiling directly above the lower level toilet, which was due to a leaky toilet above.

Figure 1 - Lower level, exterior corner @ sump

Rainwater Management: The site was relatively flat with certain areas draining towards the building. There was a compromised roof drainage system with downspouts broken off approximately four feet above grade (Figure 2).

Figure 2 - Compromised Downspout

Upper Level Bathroom: On the upper level there was evidence of mold in the bathroom above the tub (Figure 3). It appeared that this outside corner was marginally insulated and that water was condensing on the cool surface of the drywall. The bath fan was operational.

Upper Level Living Spaces: There appeared to be isolated instances of mold at outside corner wall to ceiling junctions (Figure 4). However, most of the water stains along the wall to ceiling junctions (Figure 5) appeared to be dry and were probably due to occasions of high interior humidity and cool outside temperatures, or former roof leaks. Other than aesthetically, this did not appear to be a problem at that time.

Attic: Photos of the attic sheathing showed it to be in good condition.

Occupant Issues: Occupants not available.

Figure 3 - Area above upstairs bathtub

Discussion / Recommendations:

1. Fix downspouts and conduct water away from house.
2. Fix grading around perimeter of house to shed water away from house.
3. Fix upper level toilet seal.
4. Make sure corrugated ventilation baffles are installed between all trusses and increase the insulation along the perimeter.

Figure 4 - Upper level wall/ceiling junction

Figure 5 - Water Stains on Ceiling/Wall

Inspection Number: 1-8
Resident: Vacant Unit
Address: 54227 Kinnic Kinnic Road
Model Type: Frame Split-Level
Age: Approx. 30 years old
Bedrooms: 4
Foundation: Concrete block stem wall
Heat Type: Direct vent gas forced air
Construction: 2x4 wood frame
Attic: Fiberglass Insulation

Mold and Moisture Conditions: There was mold everywhere. The former residents' food, clothes, bedding, furniture, etc. were all still present. At times, water had infiltrated the lower level, saturated clothes and wallboard, and had been left to grow mold. Extensive cleaning and repair would be required before this unit could be inhabited again.

Rainwater Management: The site was relatively flat with several areas draining back towards the house. There was a compromised roof drainage system with the downspouts broken off above grade, which have allowed the side and foundation of the building to be saturated with water.

Lower Level: This level in particular has extensive problems. The compromised downspouts have introduced water at the corners of the building and a crack in the lower level slab (Figure 2) also appears to have allowed water inside. The water had saturated clothes and anything else left on the floor and had been allowed to grow mold (Figure 3). Some mushrooms appeared on baseboards (Figure 4).

Upper Level Spaces: Although filthy, the upper level did not have nearly the same mold problem as the lower level. There were only minor instances of mold. An exterior wall to ceiling corner had some mold and there was some mold growth on vinyl window frames.

There was evidence of water condensation at the wall to ceiling junction (Figure 5), but presently everything was dry. The staining caused by the condensation could very well be from environmental tobacco smoke evidenced by

Figure 1 – Mold Stronghold

Figure 2 - Cracked Concrete Slab

Figure 3- Former resident belongings

the cigarette ashtray full of butts. The attic access hatch also had extensive staining along its perimeter indicating marginal insulation at this location.

Attic: No apparent mold or problems appeared in the attic space, but stains did appear at the attic access hatch (Figure 6).

Recommendations:

1. Fix downspouts and conduct water away from house.
2. Fix grading around perimeter of house to shed water away from house.
3. Remove drywall and anything else that was contaminated with mold in the lower level. Clean all remaining surfaces, and allow everything to dry before reattaching new finish surfaces.
4. Wipe down all vinyl windows, frames and glass with soap and water.

Figure 4 - Mushrooms at Baseboard

Figure 5 - Water Stains

Figure 6 – Stains at Attic Access Hatch

Inspection Number: 1-9
Address: 77847 Red Pine Road
Model Type: Ranch
Age: Approx. 18 years old
Bedrooms: 2
Foundation: Concrete block stem wall
Heat Type: Direct vent gas forced air
Construction: 2x4 wood frame
Attic: Fiberglass Insulation

Mold and Moisture Conditions: There was evidence of mold at several locations, predominantly at the exterior wall to ceiling junction, and some above the bathtub. The closet next to the front door had particularly thick growth of mold at the exterior wall to ceiling junction (Figure 1).

Figure 1 - Closet Exterior Wall to Ceiling Junction

Rainwater Management: The site had positive drainage away from the building and the house had gutters and downspouts. There was some mildew on the vinyl siding near the base of the wall on the north side of the building (Figure 2).

Figure 2 - Mildew on Siding

Crawl Space Conditions: Crawl space access was through a small door in the mechanical/storage room. The base of the crawl space was sand over a vapor barrier. The space was dry. No mold appeared to be growing on the block walls. The floor framing moisture content was 6%.

The band joist was well insulated with batts of insulation snuggly fit between the joists. Although this insulated the band joist, it also lowered the dew point along the perimeter. A couple of the insulation batts were removed and there was evidence of some frost on the band-joist (Figure 3), but no visible mold. The moisture content of the perimeter band joist was 20%. There might be some concern that mold could form beneath the insulation and remain concealed.

Figure 3 - Frost on Band Joist

Bathroom: There was mold above the tub surround and behind the toilet near the base of the wall.

Attic: The attic was not inspected, but based on the mold problems at the exterior wall to ceiling junction; it was likely that there was insufficient insulation along the perimeter of the roof structure. This allowed the wall to ceiling corner to be below the interior dew point and thus water condensed at this location. Conditions conducive to mold growth were thus achieved.

Occupant Issues: Occupants not available.

Mechanical Systems: The house had a heat-recovery ventilation unit.

Discussion / Recommendations: This unit was recently reroofed. The lower four feet of plywood sheathing was removed, insulation baffles were installed between all trusses, new sheathing was installed, two layers of ice and water shield were installed, the roof was reshingled, and gutters were installed.

1. Pack additional insulation along the perimeter of the house in the attic space.
2. Trim back vegetation next to the house to allow air to flow over exterior surfaces. If dirt and dust settles on the exterior walls, particularly near the base of the wall, gets wet, and does not have enough air circulating over it to dry it out, it will begin to mildew. Occasional cleaning of the siding and clearing vegetation should resolve these minor problems.
3. The high moisture content of the band-joist might also be lowered by clearing away impediments to airflow near the base of the wall.

Inspection Number: 2-1
Address: 58817 Circle Drive
Model Type: Ranch
Age: Approx. 30 years old
Bedrooms: 4
Foundation: Slab on grade
Heat Type: HW Baseboard
Construction: 2x4 wood frame
Attic: Fiberglass Insulation

Figure 1 – 58817 Circle Drive Front Elevation

Mold and Moisture Conditions: Occupant mentioned that there had been what she had thought was mold at the base of an interior wall, but there was presently no evidence of it.

Rainwater Management: The site around the house was relatively flat and the house had no gutters. Water was left to shed around the perimeter of the house. The entry pad at the front of the residence appeared to slope back towards the residence.

Bathroom: There were some water stains on the ceiling, but no mold was evident. The staining was due to occasional high humidity conditions condensing on cool surfaces. The bath fan worked.

Figure 2 - Staining on Attic Access

Attic: The attic access hatch had extensive staining on its underside (Figure 2). This was due to no insulation being present on the topside of the hatch and the hatch being located proximate to the bathroom. Humid air from the bathroom condensed on the underside of the hatch, environmental tobacco smoke would bind with the water, and once the water evaporated, the tobacco stains remained. Examination of the attic disclosed that the flexible hose coming off of the bath fan was disconnected from the roof jack and venting into the attic space.

Occupant Issues: There were five occupants in this home, four of whom smoked. None of the occupants had respiratory problems. One occupant complained that one of the bedrooms had a strange smell that had started at the end of the summer. The room contained solid wood furniture, which had been purchased last spring. The smell was not a moldy smell, but rather a woodsy smell, possibly due to the new furniture drying out.

Discussion / Recommendations:

1. Reconnect the bath fan exhaust hose to the roof jack.
2. Insulate the top of the attic access hatch.

Inspection Number: 2-2
Address: 54238 Kinnic Kinnic Road
Model Type: Bi-Level
Age: Approx. 20 years old
Bedrooms: 5
Foundation: CIP Concrete Stem Wall
Heat Type: NG Forced Air
Construction: 2x4 wood frame
Attic: Fiberglass Insulation

Figure 1 - Broken Downspout

Mold and Moisture Conditions: The house had minor mold growth at several locations. One location was due to a leaking upper level toilet. All other instances were at exterior wall to ceiling junctions.

Rainwater Management: The home had gutters, but on both elevations the downspouts were broken. On the front elevation (Figure 1), the downspout was broken such that rainwater drained right onto an exterior wall. The staining on the exterior clearly showed this occurrence. This corner was one of the interior upper corners that had mold growing on it. The rear downspout was sheared off right at the gutter (Figure 2).

Figure 2 - Broken Downspout

The site immediately adjacent to the hose was relatively flat, with some locations draining towards the house. However, there was good drainage potential to the east of the house.

Foundation Conditions: There was a sump pit in the lower level. Even at this time of year (early December) it was cycling on and off and pumping water out of the pit. Although there was water present at the foundation, evidenced by the cycling sump, the foundation wall and sump pit appeared to keep the lower level dry. There was no evidence of mold along the perimeter of the lower level.

Figure 3 - Sump Pump Discharge

The sump pump discharge on the exterior was through a PVC pipe laid directly on top of the ground. There was ice buildup where the pipe discharged onto the ground (Figure 3).

Lower Level Bathroom: There was mold on the ceiling due to a leak in the bathroom above.

Upper Level Bathroom: There was no mold present in this bathroom.

Attic: The foam baffles used to maintain airflow from the soffits into the attic space in this unit appeared to be deeper than normal (approximately three inches). This reduced the amount of insulation that could be installed at this location resulting in cold wall to

ceiling junctions, precisely the areas where mold was occurring. The temperature of the corner that had mold measured 50^0 whereas the wall surface measured 9^0 warmer, or 59^0.

Figure 4 - Lower Level Bathroom Ceiling

Discussion / Recommendations:

1. Fix the plumbing leak in the upper level bathroom and then remove and repair damaged drywall in the lower level bathroom ceiling.
2. Repair downspouts and direct water away from the building.
3. Perform minor regrading around the perimeter of the building so that water sheds away from the structure.
4. Rework sump drainage. The existing ice buildup could continue to the point that the end of the pipe would become blocked and then the water would back-up in the discharge pipe.
5. Change Propervent insulation baffles to thinner units and pack more insulation along perimeter of roof trusses.

Inspection Number: 2-3
Address: RR2 Box 378E
Model Type: Ranch
Age: Approx. 35 years old
Bedrooms: 3
Foundation: Concrete Block
Heat Type: NG Forced Air
Construction: 2x4 wood frame
Attic: Cellulose Insulation

Figure 1 - Front of House at RR2 378E

Mold and Moisture Conditions: This house had recurring seasonal mold problems. Every winter mold grew at the exterior wall to ceiling interface. There also was mold at the tub to drywall interface.

Rainwater Management: There were no gutters. The gable roof shed water at the front and back of the structure. The site had positive drainage away from the building.

Foundation Conditions: The home had a full basement with a concrete block wall foundation. There was minor cracking in some of the horizontal mortar joints, but in general the block walls appeared to be in fairly good condition. There was flaking paint near the base of the walls probably due to occasional moisture migration through the block. There is some discoloration near the base of the walls (Figure 2), but it appears to be more staining from prior water infiltration rather than mold. Currently, everything appears to be dry. There was no sump pump.

Figure 2 - Discoloration at Base of Basement Wall

Mechanical Systems: This home had a natural gas forced-air heating system with a wood-burning stove attached to the air distribution system. Fuel for the stove was kept in the basement (Figure 3). Combustion exhaust from the forced air unit ran through a PVC pipe run horizontally through the rim joist. To keep water, snow, leaves and other contaminants out of the end of the exhaust, a 90^0 elbow was installed on the end of the pipe and directed downward. This exhaust blew directly into a window well. Warm moist air was immediately condensing all over the basement window and surrounding surfaces (Figure 4).

Figure 3 - Firewood Storage in Basement

Bathroom: There was mold growing at the junction between the tub and the drywall (Figure 5). This appeared to be from water splashing out of the tub, saturating the wallboard, and then growing mold.

Figure 4 - Furnace Exhaust into Window Well

Attic: There was approximately sixteen inches or more of blown-in cellulose insulation throughout the attic except near the eaves. Insulation baffles were not visible from the attic access hatch. The roof sheathing appeared dry and in good condition.

Occupant Issues: This occupant maintained an impeccably clean residence and kept mold growth in check. She stated that she had recurring sinus problems during the winter months.

Figure 5 - Mold at Edge of Bathtub

Figure 6 - Moisture on Plastic Window Covering

Discussion / Recommendations:

1. Based on the amount of moisture present on the inside of the plastic film stretched over the exterior of the windows (Figure 6), there must be a moisture source on the interior of the building. Much of this moisture could be emanating from the large stockpile of firewood stored in the basement. Exterior storage for the primary bulk of wood would be preferred, with only a few day supply kept indoors.

2. Moisture from the heating system exhaust could also be finding its way inside. The heating system exhaust should be extended and pointed away from the window well.

3. Based on the condensation on the windows, and high moisture load, a Heat Recovery Ventilation system with humidistat control would introduce fresh air during winter months while scavenging energy from the exhaust air stream.

4. Occupant's sinus problems should be addressed. The assessment team does not have expertise in medical diagnosis, and does not offer opinions on health symptoms and their causes.

Inspection Number: 2-4
Address: 77850 Firebreak Road
Model Type: Ranch
Age: Approx. 22 years old
Bedrooms: 3
Foundation: Concrete Block
Heat Type: NG Forced Air
Construction: 2x4 wood frame
Attic: Fiberglass Insulation

Figure 1 - 77850 Firebreak Road

Mold and Moisture Conditions: The only mold in this residence was adjacent to the base of the bathtub by the toilet (Figure 2).

Rainwater Management: There were no gutters except for a small open-ended section above the front door. The gable roof shed towards the front and rear of the residence. The site had positive drainage away from the building.

Figure 2 - Mold at Bathtub

Foundation Conditions: The concrete block crawl space had a sand floor over a vapor barrier and was dry. Moisture content of the floor framing measured six to nine percent. There was no sump pump.

Bathroom: This was the only room of the house with mold. On the plumbing end of the bathtub, at the base of the of the tub assembly, the drywall appeared to have swelled due to water saturation and was presently growing mold. The caulk seal at the base of the bathtub to vinyl flooring was old, dried-out and cracked, and allowed water into the floor assembly.

Attic: Not examined.

Occupant Issues: There were two adults and five children in this residence. There were no smokers. The children had allergies and the mother was allergic to "everything".

Mechanical Systems: Heating was from a natural gas forced-air furnace and an independent heat-recovery unit.

Discussion / Recommendations:

1. Remove and repair damaged drywall at base of tub by toilet.

2. Remove old caulk, clean joint, and recaulk joint between tub and flooring material.

Inspection Number: 2-5
Address: Bad River
Model Type: Ranch
Age: 30+
Bedrooms: 3
Foundation: Concrete Block Crawl Space
Heat Type: Forced Air
Construction: 2x4 wood frame
Attic: Fiberglass Insulation

Figure 1 – not available

Mold and Moisture Conditions: The principal affected area was the substandard shed room at the back of the house (Figure 1& 2). The crawl space, which could not be accessed, was a likely source of moisture.

Figure 2 – Mold growth on shed walls as consequence of substandard cladding.

Rainwater Management: There were no gutters. The soil slope was negative and was not correctible. We were told that the building had been raised in the past. It appears that a large quantity of rainwater often gets into the crawl space.

Foundation Conditions: All signs in the house indicated a wet crawl space as a chronic condition. The band joist of the floor framing was severely rotted. The discharge pipe from the sump pump was frozen at the time of the inspection. The foundation suffered from recurrent flooding. The sump pump needed repeated repair.

Bathroom: The fan did not work. There were no apparent leaks. There was some discoloration in the upper corner next to the shower/tub, and a small amount of mold at the base between the tub and toilet.

Figure 3 – Dark attic sheathing affected by crawl space water. Note new sheathing panel.

Attic: Rather severe rotting of the attic sheathing. Several sheathing panels had been replaced at the time of the recent re-roofing. There was extensive water spotting on the ceiling, a consequence of condensation of crawl space moisture on the attic sheathing (Figure 3 & Figure 4).

Occupant Issues: The housekeeping was excellent. The occupant and family were very attached to the house despite the chronic severe water problems in the house. The occupant scrubbed wall and window surfaces very often, and used a commercial mold cleaner. Mold problems occur, apparently, in all seasons. Family members are said to suffer from allergies, sneezing, runny noses, rhinitis, and eye inflammation. There was one smoker in the home.

Mechanical Systems: The home was heated with natural gas forced-air.

Figure 4 – Ceiling water spotting, a consequence of attic condensation.

Discussion / Recommendations: This was a special case. The family was very attached to the home. However, the water problems are severe and chronic. This situation was in stark contrast to homes with little or no mold problem and occupants sought to move.

Inspection Number: 2-6
Address: Bad River
Model Type: Ranch
Age: unknown
Bedrooms: 4 children + mother
Foundation: Concrete Block Crawl Space
Heat Type: NG Forced Air + heat exchanger
Construction: 2x4 wood frame
Attic: cellulose insulation

Figure 1 – Ceiling-wall joint showing darkening at truss locations.

Mold and Moisture Conditions: Minor problems occurred primarily at wall-ceiling junctions (Figure 1).

Rainwater Management: It was overall moderate to good. No gutters were present except over the entry doorway.

Foundation Conditions: The building was on a tall crawl space. There was a poly soil cover with sand ballast. One corner was slightly wet. Cobwebs made the space uncomfortable for visits (Figure 2). There may have been wetness events in the crawl space, given the conditions described below. There was no sump pump. Moisture content at band joist measured 9% and 6% at the joists.

Figure 2 – Dry tall crawl space. However, cobwebs make the crawl space unpleasant to visit for maintenance and repair.

Bathroom: The fan was operational. There was discoloration at the ceiling wall junction in all of the rooms at the perimeter of the house, including the bathroom.

Kitchen: The exhaust fan was operational.

Attic: No problem was found.

Occupant Issues: There was room for improvement in housekeeping. Occupants were not available for interview.

Mechanical Systems: The home was heated by natural gas forced-air with a heat exchanger.

Discussion / Recommendations:

Spotting at the ceiling-wall junction should be addressed by continued monitoring of the crawl space condition and improved insulation at the top plate.