HOUSING ANALYSIS IN QUINHAGAK, ALASKA

Prepared for:
The Native Village of Kwinhagak (NVK)

in cooperation with:
Rural Community Development Consultants
1120 Huffman Road, Ste. 24 #612
Anchorage, AK, 99515
(907) 345-7232

Prepared by:
the Cold Climate Housing Research Center
P.O. Box 82489
Fairbanks, AK, 99708-2489
(907) 457-3454

and

PDC Engineering, Inc.
1028 Aurora Dr.
Fairbanks, AK, 99709
(907) 452-1414
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September 9, 2009

Wassillie Bavilla, President
The Native Village of Kwinhagak

Site Inspections and Recommendations Report

Executive Summary

On request of the Native Village of Kwinhagak a team from the Cold Climate Housing Research Center visited the village on September 2 – 4, 2009. The team consisted of myself, President/CEO acting as Senior Building Scientist; Aaron Cooke, Architectural Designer/Project Manager; and Elliot Wilson, Engineer with PDC Engineering. Prior to the visit our team reviewed the Residential Building Inspection Report and photographs provided by Advance Look Building Inspections. My initial interpretation was that this was a very serious situation that would require a visit to the village to see the damage first hand. It was our hope that the reports reflected the worst case scenario.

We were asked to survey and analyze 55 homes that were delivered in the 1970’s and retrofitted in the 1990’s. A ten home sample was selected by the housing director for an in-depth analysis of the structural integrity, building envelope condition, and interior environment typical to this housing stock. It was the intent of the housing director that this house sample represented the full spectrum of physical conditions to include “worst off” and “better off” examples.

Unfortunately, upon field examination, we determined that the thermal and structural integrity is severely compromised in all sample homes. Our visit revealed a real concern that these structures may be unsafe for occupancy. These concerns involve inhabitant’s physical safety due to the soundness of the structure and health safety due to the presence of mold. Mold is prolific throughout all structures. In addition to the safety of the houses, is the concern that the cost to heat these homes to a livable and safe level is a huge burden on the occupant.

A tight interior building envelope coupled with a lack of ventilation has created conditions where mold growth and serious decay of the structures is endemic. The building wall cavities and insulation are continually being exposed to high humidity and condensation. The wall construction will not allow drying to occur at any time of the year. In addition to high levels of humidity and seasonal condensing events in the wall cavity generated from the interior of the buildings, from the exterior, water intrusion due to poor flashing detail, absence of eaves and gutters, and poorly maintained surface finishes allows soaking of sheathing and structural lumber whenever there is any rainfall. These homes literally never have an opportunity to dry. The structure’s organic components are saturated or near saturated in some areas continuously. It should be no surprise that after thirty years these building are exhibiting eminent catastrophic failure.

CCHRC Internet Web Site: http://www.cchrc.org
P.O. Box 82489, Fairbanks, AK 99708 Phone: (907)457-3454 Fax: (907)457-3456
The expense of remediation, repair, and renovation may well approach or exceed the cost of new construction. Economic considerations should be looked at seriously before any major work is done. However, as our report points out, there are some safety issues that should be addressed immediately, regardless of long term strategies. In particular, the entry porches and stairs must be brought to a minimal level of soundness to protect occupants from possible serious injury or death.

The period of time that any of these homes can continue to be occupied is very short and in some cases has arrived. It is imperative that the community work closely and immediately with other concerned individuals and organizations to address this real crisis. The cost of new construction and energy in Rural Alaska has escalated well beyond what is affordable or even possible to meet an escalating need. Real innovation will have to be explored if a brighter future is to be realized. This must involve a collaborative effort with the community, designers, researchers, potential funders, state and federal agencies, and construction professionals.

Please contact us if we can clarify our findings further or assist in any way.

Sincerely,

Jack Hébert
President/CEO
Architectural Analysis

Summary:
The initial 70s era construction assembly of the housing stock analyzed in Quinhagak was insufficient to handle the climatic, heating, and occupancy loads of rural Western Alaska. As a result, the exterior envelopes of the buildings have been completely compromised, the sites are experiencing significant subsidence, mold and rot have infiltrated the homes, and they are too difficult to heat effectively. The retrofit of the 1990s that was meant to rectify this situation instead compounded the problem. Water infiltration and mold are extensive, air quality is poor, and the buildings are failing their inhabitants thermally, structurally, and economically. We conclude that the widespread use of these homes has created a problem of crisis proportions for the village: they are for all practical purposes unsalvageable, yet to condemn them all would leave roughly one third of the village without shelter.

Construction Type
The homes analyzed in Quinhagak are ranch-style, stud frame-construction that were delivered pre-constructed in two halves and then assembled on site. The homes are approximately 1000 square feet, rectangular, and oriented along a roughly East-West axis so as to expose one of the long sides of the home to the South. The buildings rest on cylindrical wood piles that were initially 36-48 inches above grade but the ground has since subsided to create heights up to 72-84 inches. Girders carry the weight of the structure to the piles, with joists hanging from the girders in the perpendicular direction. The original design was 2x6 stud framing with a vapor barrier and sheathing, truss roofs and corrugated metal roofing material. The roofs do not have eaves or gutters. The original walls were filled with faced Fiberglass batting insulation with an approximate thermal resistance of R-19. The ceiling was initially laid with faced Fiberglass batting insulation for an approximate thermal resistance of R-19.

During the weatherization retrofit that took place in the 1990’s, 1” of foil faced polyurethane board “Blackcore Celotex” insulation and T-111 type strand board sheathing were added to the outside of the studs. Another layer of R-13 insulation was also added to the ceiling. ½” Oriented-Strand-Board (OSB) was placed under the floor joists in all homes except one, which was sprayed with polyurethane foam.

Figures 1 and 2: Typical elevations of the homes analyzed in Quinhagak.
Exterior Envelope Damage

In all the homes analyzed, the exterior envelope has been severely compromised by water infiltration. Moisture content readings were performed on each of the homes. Moisture content was measured at 1) The structural girder under the wall, 2) The lower edge of the exterior sheathing of the wall, 3) The exterior sheathing 2' up on the wall, and 4) the interior sheathing of the wall at 2' above the bottom edge. Acceptable levels of moisture content in construction-grade lumber generally fall below 15%. Anything above 20% is considered susceptible to mold and rot. The girders in the homes analyzed consistently were at or surpassed 40% moisture content (The Moisture Content Sensor does not read moisture content levels above 40%). In many cases we observed total saturation. The lower edge of the exterior sheathing on the wall also consistently rated at or above 40% moisture content. The exterior sheathing at 2' above the bottom edge averaged 29.9% moisture content. On the south side of the house, the exterior sheathing held less moisture content than the north side of the house due to drying from solar exposure. However, the interior sheathing on both sides was equally saturated, showing that the interior of the wall was not able to dry even in warm conditions.

The contributing factors to this extremely high rate of water infiltration include the complete lack of eaves and gutters on the homes, the double vapor barrier that was a product of the retrofit, and the building’s complete inability to dry itself through heating or solar exposure.

Figure 3: Extensive mold growth on the north facade.
The lack of eaves or gutter has created water damage to the home, and the problem was exacerbated with the retrofit of the 1990’s. With more than 1½” added to the wall section and no eaves extension, water is allowed to run freely not only down the outside of the envelope, but also within it. Water drains down the outside of the wall and saturates the bottom of the exterior sheathing and structure. It is then wicked back up the wall, filling the cavity with moisture.

The addition of the foil face celotex to the home during the energy retrofit had similarly catastrophic consequences. The double vapor barrier created by the rigid foam board does not allow drying to the exterior even when conditions are favorable. This creates a situation in which the wall very efficiently traps water, holds condensation, and creates an ideal home for mold.

The combination of the double vapor barrier, lack of eaves, high occupancy load, high Delta-T (difference between outdoor and indoor temperatures), and wet climate prohibit the building from ever drying. In the winter, there is too much humidity and not enough heat to allow the building to dry from the inside. The wet climate and double vapor barrier prohibit drying from the outside. This explains why, even on sunny days when the exterior sheathing on the southern face of the building held less moisture than the northern side, the interior sheathing was still just as saturated.
Mold

The community described anecdotally presence of mold before the initial visit by CCHRC and PDC Engineering. A mold remediation crew had been sent to Quinhagak, and separate reports on mold growth were submitted by Advance Look Building Inspections & Environmental Testing and Advanced Indoor Diagnostics in June and August 2009, respectively. This report documents the extensive presence of mold in the exterior, interior, and wall cavity of the typical home. We agree with the findings of this report.

On the exterior envelope, mold is found to be most prominent on the northern façade of the homes, as that side receives the least light and has the least ability to dry. Visible mold has formed on the top of windows and stains the entirety of North-facing sheathing on the façade. In the interior of the home, mold is common around window frames, in the corners of the home farthest from the heating appliance and closest to the joint of roof and wall. This is likely because these areas of the home are most susceptible to cold and damp due to distance from the heating source and lack of an energy heel on the roof. Without an energy heel on the truss, insulation cannot be easily laid at the corner above the wall to an adequate depth.

Figure 7: Extensive mold growth on north facade.

Figure 8: typical mold growth on window.
Subsidence

In the typical homes analyzed in Quinhagak, the soil surrounding the home had subsided from under the building, creating standing water around the base of the building, typically at the south side. Subsidence occurs when heat begins to melt the frozen ground around the pilings, causing the level of grade to fall away from the building. The homes analyzed in Quinhagak have subsidence issues on the south face of the property. Of the ten homes analyzed, six were experiencing significant subsidence issues. In the buildings experiencing subsidence, the difference in grade height between the north pilings and south pilings averaged 19.5”. Although such subsidence can create problems with standing water and eventually expose enough of the pilings to create a structural problem, this issue is not nearly as pressing as the water infiltration, mold, and heating problems present in the homes.

One specific area that is significantly pressing is subsidence under the arctic-entryway, which has left the typical entryway unsupported and dangerous. For a detailed account of this problem area, please see the engineering report.

Figure 11: subsidence of the earth has led to more than six feet of exposed pilings.
Implications for Heating Load/Ventilation

The interior spaces of the homes analyzed in Quinhagak are below a standard that would be considered acceptable in terms of keeping out the cold and damp. Although not tested specifically by CCHRC or PDC Engineering, it seems very likely that mold growth leads to an unacceptable level of air quality in the home as well. Residents primarily use heating oil to heat their homes. Additionally, residents are pressed to search out wood to supplement their heating load. Each home analyzed in Quinhagak had both a Toyo-style heater and a traditional wood stove. There are no trees in Quinhagak, and residents must travel three hours to the mountains on snowmachine to collect wood for supplemental energy. The water-saturated nature of the wall section makes the home nearly impossible to heat properly in the winter. Typical homes in this sample use 110 gallons of heating oil per month, and some surveyed needed to use that amount nearly every two weeks during the coldest part of winter. This can lead to heating bills of up to $900 a month in the winter. The median family income level in Quinhagak is $25,313, and roughly 26% of the community is below poverty line. There is little conceivable way for the current inhabitants of the buildings to be able to properly heat them with the resources present and the nature of the construction.

Figure 10: Visible mold growth at the under-insulated truss-wall connection point

Figure 11: Typical wood stove found in most residences visited.
Summary:

Due to the extensive water damage from external and internal water infiltration, massive deterioration of structural elements has occurred in each of the ten structures selected for review. In all cases, the structural components integral in the vertical and lateral force resistant systems have substantially deteriorated not only to the point where the serviceability of the structure has been compromised, but now must be considered first and foremost a safety concern for the occupants. It is the conclusion of this report that the structures are unfit for human occupancy and are most likely beyond the state of repair.

Sincerely,

Jim Loftus, PE

Elliot Wilson, EIT

Vertical Force Resistant System:

Structural Glue-Lam Beam

All the 1970's era homes were built in the same style with a 5 1/8" x 13.5" Glulam for the rim joist and load dispersing mechanism from the structure to the pilings. To today's code assuming International Building Code 2006 (IBC 06), loading conditions would have sized structural beams as 5 1/8 x 15" making the existing size inadequate. The visual inspection of these gluelams showed behavior consistent with being undersized with deflections ranging from 1/4" to as much as 2.5". Deflections in excess of 1/4" in this case cannot be accomplished by loading alone under normal conditions. Upon further investigation, it was determined that extensive rot was increasing the curvature of the beam at the locations of higher internal moment namely around the center of the 3 pilings supporting the gluelam beam.
Floor Joists

Floor joist were 2x8 nominal members spaced at 16” on center. The glulam to floor joist connection consisted of a typical face mounted steel hanger commonly sold by Simpson Strong Tie. In a few locations, excessive deflections were seen in the floor joists, but for the most part, from visual inspection the members themselves seem to have had limited deterioration. Calculating the needed depth of floor joist in a similar manner to the sizing of the structural glulam shows again that the existing members are a little undersized for strength requirements based on IBC 06, but it is more likely that failure will be first seen in the structural interface between the hanger and the glulam beam.
Because the hangers only face-mount and do not have a horizontal ledger to bear on top of the glulam, the entirety of the force transfer is in the shearing of the nails that are imbedded in the deteriorated wood of the glulam.

Entryway and Access

The entryways, generally 4’x4’ structures adjacent to the building, are by far the most troubling and immediate concern in regards to deficiencies in the vertical force resistant system. Caused from the settling of ground around the entirety of the structure, posts that once connected the entryway to the ground are now either suspended or missing. As a result, the entryways are mostly or entirely supported as a cantilevered element off the main building. Because the entryways were once supported by the posts only minimal fasteners attach the entryway to the house framing. This deficiency in structural integrity is seen in noticeable disconnecting and deflection of the entryway. In addition, the stairs attached to the entryways which often rise more then 6 feet are only attached with a single nail on each side into rotten wood. It is my recommendation that immediate action is taken to address these severely inadequate methods of construction because sudden failure in the limited existing structural components may lead to injury and/or death.

Figure 3: Poorly attached stair to entryway.
Figure 4: No support posts under entryway.

Fuel Storage Tanks

All the houses visited had 'Toyo' heating units which rely on a gravity feed for fuel delivery from the storage tank. The top of floor joists was typically over 6-7 feet above grade, making the needed height of the fuel tank at the bare minimum 7.5-8.5 feet for adequate head pressure. This height makes fuel deliveries dangerous and difficult. Most tanks are supported by rather makeshift fastening systems connecting the tank to the wall of the dwelling. Two typical systems seem to be used: a plywood gusset assembly or a steel frame attached to the building with large lag screws. Both systems are severely inadequate, and need to be addressed. If not addressed, there is real concern that accidental spillage and possible environmental contamination, as well as serious human injury while climbing on the assembly to fill the tanks might occur.
Later Force Resistant Systems

It is quite obvious from the design of the 55 1970’s era homes little thought was put into the lateral resistant system. The pilings have not been cross-braced, making even walking on the structure create notable vibration and side sway. The lateral resisting system that was designed is no longer capable of providing the needed shear and uplift capacity for design wind events. Because of the severe drooping in the glulam beam, the bottom plate has completely disconnected from the glulam beam making the shear transfer via nails no longer in effect. Due to the installation of additional insulation and vapor barrier during the retrofit in 1994, extensive rotting on the interior shear panels has occurred. This rot has deteriorated the shear transfer between the panels and the wall elements by reducing the effectiveness of the staple to transfer shear. In most locations the original shear transfer between the building and the pilings is intact, but where settling or drifting of piling has occurred, adequate shear transfer is missing. This is seen on entryways and center support pilings. Due to the nature of lateral force failures occurring during extreme wind or seismic events, it is very likely that simultaneous failure of many homes of this style could occur.
Figure 6: Example of deterioration of shear interface (photo taken of bottom plate from exterior with sheathing removed).
APPENDIX: HOUSE-BY-HOUSE DOCUMENTATION

Cold Climate Housing Research Center
On Site Inspection of 70 Era Homes of Quinhagak
September 3, 2009

PDC Inc. Engineers
On Site Inspection of 70s Era Homes of Quinhagak
September 3, 2009
Cold Climate Housing Research Center
On Site Inspection of 70 Era Homes of Quinhagak
September 3, 2009

**House # 67**

**Site Conditions:**
- **Standing Water:** On North and South
- **Subsidence:** 8” on South

**Arctic Entry:** Visible fatigue, no support

**Floor Diaphragm:**
- **Condition:** Intact
- **Underside:** Moderate water damage

**Visible Mold:**
- **Exterior:** Extensive mold on north facade
- **Interior:** Extensive mold visible

**Wall Moisture Content:**
- **Girder:** 34%
- **Base of Exterior Sheathing:** 32%
- **Exterior Sheathing 2’ up:** 32% (South)
- **Interior Sheathing 2’ up:** 40% (South)

**Gutters:** No

**Window Damage:** Extensive

Figure 1: North elevation
Figure 2: South and west facades
Figure 3: Extensive window damage
Figure 4: Mold growth at cold joints
House #67

South Side:

Pilings:
- **Type:** 10" Diameter 16' oc <= Considered Typical Section
- **Condition:** Satisfactory
- **Orientation:** Strait
- **Connections:** ½" Lag bolts

Glulam:
- **Type:** 5 1/8" x 13 ½"
- **Condition:** Completely Deteriorated
- **Deflection:** 2" in 1.5' from center support

Sheathing: Saturated and visible organic growth

North Side:

Pilings:
- **Type:** Typical
- **Condition:** Satisfactory
- **Orientation:** 1 of three has drifted but still in plane
- **Connections:** ½" Lag bolts

Glulam:
- **Type:** 5 1/8" x 13 ½"
- **Condition:** Completely Deteriorated
- **Deflection:** 3/4" in 7" from center support

Sheathing: Saturated and visible organic growth

Common Elements:

Studs:
- **Type:** 2x6
- **Condition:** Extensive Rot

Secondary Elements:

Fuel Tank: Satisfactory
Entry Way: No support legs
Cold Climate Housing Research Center
On Site Inspection of 70 Era Homes of Quinhagak
September 3, 2009

**House # 70**

**Site Conditions:**
- **Standing Water:** No
- **Subsidence:** 38” on South

**Arctic Entry:** No structural support, ground has subsided.

**Floor Diaphragm:**
- **Condition:** Intact
- **Underside:** Dry

**Visible Mold:**
- **Exterior:** Extensive mold on north facade
- **Interior:** Extensive mold visible

**Wall Moisture Content:**
- **Girder:** 40%
- **Base of Exterior Sheathing:** 40%
- **Exterior Sheathing 2’ up:** 30% (South)
- **Interior Sheathing 2’ up:** 38% (South)

**Gutters:** No

**Window Damage:** Extensive

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Figure 5: Rot and mold visible in window

Figure 6: Completely deteriorated glulam

Figure 7: Saturated exterior sheathing

Figure 8: Arctic entry lacks structural support
House #70

South Side:
Pilings:
  Type: Typical
  Condition: Satisfactory
  Orientation: Strait
  Connections: ½" Lag bolts

Glulam:
  Type: 5 1/8" x 13 ½"
  Condition: Completely Deteriorated
  Deflection: 1"

Sheathing: Saturated and visible organic growth

North Side:
Pilings:
  Type: Typical
  Condition: Satisfactory
  Orientation: Satisfactory
  Connections: ½" Lag bolts

Glulam:
  Type: 5 1/8" x 13 ½"
  Condition: Completely Deteriorated
  Deflection: 1/4"

Sheathing: Saturated and visible organic growth

Common Elements:
  Studs:
    Type: 2x6
    Condition: Extensive Rot

Secondary Elements:
  Fuel Tank: ½” plywood gusset plate in compression for 500 gallon tank.
  Entry Way: No support legs
  Stairs: Mounted by single nail through hinge, rotten and no handrail.
House # 71

Site Conditions:
- Standing Water: Yes
- Subsidence: 18” on South

Arctic Entry: Posts put on spacers, old stair failed from subsidence, new stair installed

Floor Diaphragm:
- Condition: Intact
- Underside: Slightly damaged from water

Visible Mold:
- Exterior: Extensive mold visible on North facade
- Interior: Moderate amounts of mold visible

Wall Moisture Content:
- Girder: 40%
- Base of Exterior Sheathing: 40%
- Exterior Sheathing 2’ up: 20% (South)
- Interior Sheathing 2’ up: 25% (South)

Gutters: No

Window Damage: Moderate

Figure 9: Old and new stairs due to subsidence

Figure 10: No support on entry led to structural shearing

Figure 12: Pile-glulam connection deteriorated

Figure 11: Extensive mold growth on north facade
House #71

South Side:
  Pilings:
    Type: 3 typical pilings
    Condition: Satisfactory
    Orientation: Strait
    Connections: ½” Lag bolts

Glulam:
  Type: 5 1/8” x 13 ½”
  Condition: Completely Deteriorated
  Deflection: ½”

Sheathing: Saturated and visible organic growth

North Side:
  Pilings:
    Type: 3 typical pilings
    Condition: Satisfactory
    Orientation: Strait
    Connections: ½” Lag bolts

Glulam:
  Type: 5 1/8” x 13 ½”
  Condition: Completely Deteriorated
  Deflection: 1/4”

Sheathing: Saturated and visible organic growth

Common Elements:
  Studs:
    Type: 2x6
    Condition: Extensive Rot

Secondary Elements:
  Fuel Tank: ½” plywood gusset plate in compression.
  Entry Way: No support legs
  Stairs: Mounted by single nail through hinge and rotten.
House # 82

Site Conditions:
Standing Water: No
Subsidence: 22” on South

Arctic Entry: No supports, less visible fatigue than most

Floor Diaphragm:
Condition: Intact
Underside: Sprayed Polyurethane (unique)

Visible Mold:
Exterior: Extensive mold on north side
Interior: Moderate

Wall Moisture Content:
Girder: 40%
Base of Exterior Sheathing: 40%
Exterior Sheathing 2’ up: 25% (South)
Interior Sheathing 2’ up: 25% (South)

Gutters: Ad hoc gutter on north side

Window Damage: Moderate

Figure 13: Extensive mold on north side

Figure 14: Arctic entry without supports

Figure 16: Interior of home maintained by occupant

Figure 15: Visible mold on interior of home
House #82

South Side:
  Pilings:
    Type: 3 typical pilings
    Condition: Satisfactory
    Orientation: Strait
    Connections: \( \frac{1}{2}" \) Lag bolts

  Glulam:
    Type: 5 \( 1\frac{1}{8}" \) x 13 \( \frac{1}{2}" \)
    Condition: Completely Deteriorated
    Deflection: \( \frac{1}{2}" \)

  Sheathing: Saturated and visible organic growth

North Side:
  Pilings:
    Type: 3 typical pilings
    Condition: Satisfactory
    Orientation: Strait
    Connections: \( \frac{1}{2}" \) Lag bolts

  Glulam:
    Type: 5 \( 1\frac{1}{8}" \) x 13 \( \frac{1}{2}" \)
    Condition: Completely Deteriorated
    Deflection: \( \frac{1}{2}" \)

  Sheathing: Saturated and visible organic growth

Common Elements:
  Studs:
    Type: 2x6
    Condition: Extensive Rot

Secondary Elements:
  Entry Way: No support legs
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House # 85

Site Conditions:
  Standing Water: Yes
  Subsidence: 9” on west side

Arctic Entry: Multiple, home-made supports

Floor Diaphragm:
  Condition: visible holes in the floor, saturated joists
  Underside: Dry

Visible Mold:
  Exterior: Extensive mold
  Interior: Extensive mold

Wall Moisture Content:
  Girder: 40%
  Base of Exterior Sheathing: 39%
  Exterior Sheathing 2’ up: 36%
  Interior Sheathing 2’ up: 40%

Gutters: No

Window Damage: Extensive

Figure 17: North facade

Figure 18: Visible holes in floor, saturated joists

Figure 19: Visible leakage in the ceiling

Figure 20: Saturated sheathing
House #85

South Side:
    Pilings:
        Type: 3 typical pilings
        Condition: Satisfactory
        Orientation: Strait
        Connections: ½” Lag bolts

Glulam:
    Type: 5 1/8” x 13 ½”
    Condition: Completely Deteriorated w/ 2” diameter holes cut at center support
    Deflection: 2 ½”

Sheathing: Saturated and visible organic growth

North Side:
    Pilings:
        Type: 3 typical pilings
        Condition: Satisfactory
        Orientation: Strait
        Connections: ½” Lag bolts

Glulam:
    Type: 5 1/8” x 13 ½”
    Condition: Completely Deteriorated
    Deflection: 1/2”

Sheathing: Saturated and visible organic growth

Common Elements:
    Studs:
        Type: 2x6
        Condition: Extensive Rot

Secondary Elements:
    Entry Way: Minimal or missing support legs
    Inside Floor: Deflects 2” when walking on.
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On Site Inspection of 70 Era Homes of Quinhagak
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**House # 92**

**Site Conditions:**
- **Standing Water:** No
- **Subsidence:** No

**Arctic Entry:** Some fatigue, resident has installed a support but it has subsided.

**Floor Diaphragm:**
- **Condition:** Large visible holes in floor, visible rotting joists
- **Underside:** Dry

**Visible Mold:**
- **Exterior:** Moderate
- **Interior:** Extensive

**Wall Moisture Content:**
- **Girder:** 40%
- **Base of Exterior Sheathing:** 40%
- **Exterior Sheathing 2’ up:** 26% (West)
- **Interior Sheathing 2’ up:** 40% (West)
  Building is oriented North South, unlike the typical building

**Gutters:** No

**Window Damage:** Extensive

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**Figure 21:** Sheathing has fallen off, exposing insulation

**Figure 22:** Visible holes in the floor

**Figure 23:** Visible leaks in the ceiling

**Figure 24:** extensive interior mold
House #92

West Side:
   Pilings:
      Type: 3 typical pilings
      Condition: Satisfactory
      Orientation: Strait
      Connections: ½” Lag bolts

   Glulam:
      Type: 5 1/8” x 13 ½”
      Condition: Completely Deteriorated can pull off pieces by hand
      Deflection: 1 ½”

      Sheathing: Saturated and visible organic growth

East Side:
   Pilings:
      Type: 4 typical pilings
      Condition: Satisfactory
      Orientation: Strait
      Connections: ½” Lag bolts

   Glulam:
      Type: 5 1/8” x 13 ½”
      Condition: Moderately Deteriorated

      Deflection: 1/2”

      Sheathing: Saturated and visible organic growth

Common Elements:
   Studs:
      Type: 2x6
      Condition: Extensive Rot

Secondary Elements:
   Fuel Tank: Steel Frame which is most likely only lagged into rotten sheathing.
   Entry Way: Failed
   Stairs: Sloped, rotten and with out handrail.
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September 3, 2009

**House # 100**

**Site Conditions:**
- **Standing Water:** Yes
- **Subsidence:** Approximately 20” to south

**Arctic Entry:** Solid

**Floor Diaphragm:**
- **Condition:** Visible holes
- **Underside:** Some wet spots

**Visible Mold:**
- **Exterior:** Extensive
- **Interior:** Extensive

**Wall Moisture Content:**
- **Girder:** 40%
- **Base of Exterior Sheathing:** 40%
- **Exterior Sheathing 2’ up:** 38%
- **Interior Sheathing 2’ up:** 40%

**Gutters:** No

**Window Damage:** Extensive

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Figure 25: South elevation

Figure 26: Extensive mold on north facade

Figure 27: Joists completely saturated

Figure 28: Glulam completely saturated
House #100

South Side:

Pilings:
  Type: 3 typical pilings
  Condition: Satisfactory
  Orientation: 1 off w/ shoring placed
  Connections: ½” Lag bolts

Glulam:
  Type: 5 1/8” x 13 ½”
  Condition: Completely Deteriorated
  Deflection: 3/4”

Sheathing: Saturated and visible organic growth

North Side:

Pilings:
  Type: 3 typical pilings
  Condition: Satisfactory
  Orientation: Strait
  Connections: ½” Lag bolts

Glulam:
  Type: 5 1/8” x 13 ½”
  Condition: Completely Deteriorated
  Deflection: 5/8”

Sheathing: Saturated and visible organic growth

Common Elements:

Studs:
  Type: 2x6
  Condition: Extensive Rot
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**House # 102**

**Site Conditions:**
- **Standing Water:** Surrounded by standing water
- **Subsidence:** No

**Arctic Entry:** No visible support

**Floor Diaphragm:**
- **Condition:** Did not enter the interior of home
- **Underside:** Dry

**Visible Mold:**
- **Exterior:** Moderate
- **Interior:** Did not enter the interior of home

**Wall Moisture Content:**
- **Girder:** 27%
- **Base of Exterior Sheathing:** 20%
- **Exterior Sheathing 2’ up:** 18%
- **Interior Sheathing 2’ up:** 18%

**Gutters:** Yes

**Window Damage:** Moderate
House #102

South Side:
  Pilings:
    Type: 3 typical pilings
    Condition: Satisfactory
    Orientation: Strait
    Connections: ½" Lag bolts

  Glulam:
    Type: 5 1/8” x 13 ½”
    Condition: Completely Deteriorated
    Deflection: 3” 1’ from center support

  Sheathing: Saturated and visible organic growth

North Side:
  Pilings:
    Type: 3 typical pilings
    Condition: Satisfactory
    Orientation: Strait, except one have shifted vertically
    Connections: ½” Lag bolts, 1 of 3 not connected

  Glulam:
    Type: 5 1/8” x 13 ½”
    Condition: Completely Deteriorated
    Deflection: 1” with a simple span because center piling has is not bearing

  Sheathing: Saturated and visible organic growth

Common Elements:
  Studs:
    Type: 2x6
    Condition: Extensive Rot

Secondary Elements:
  Fuel Tank: ½” plywood gusset plate in compression.
  Entry Way: No support legs
  Stairs: Rotten.
Cold Climate Housing Research Center
On Site Inspection of 70 Era Homes of Quinhagak
September 3, 2009

House # 105

Site Conditions:
Standing Water: Standing water on south and west
Subsidence: 16” on south

Arctic Entry: subsidence caused damage

Floor Diaphragm:
Condition: Intact
Underside: Dry

Visible Mold:
Exterior: Extensive mold on the north side
Interior: Moderate

Wall Moisture Content:
Girder: 40%
Base of Exterior Sheathing: 27%
Exterior Sheathing 2’ up: 20% (South)
Interior Sheathing 2’ up: 32%

Gutters: Partial

Window Damage: Extensive

Figure 33: Subsidence-caused damage to arctic entryway

Figure 34: Completely saturated girder

Figure 35: Undersized new beam

Figure 36: Extensive rot on north side
House #105

South Side:
  Pilings:
    Type: 3 typical pilings
    Condition: Satisfactory
    Orientation: Middle moved out
    Connections: ½” Lag bolts

  Glulam:
    Type: 5 1/8” x 13 ½”
    Condition: Completely Deteriorated and replaced with undersized new beam to side
    Deflection: Old beam failed in shear:

  Sheathing: Saturated and visible organic growth

North Side:
  Pilings:
    Type: 3 typical pilings
    Condition: Satisfactory
    Orientation: Strait
    Connections: ½” Lag bolts

  Glulam:
    Type: 5 1/8” x 13 ½”
    Condition: Completely Deteriorated w/ 2” dia holes cut within 1 inch of top
    Deflection: 3/4”

  Sheathing: Saturated and visible organic growth

Common Elements:
  Studs:
    Type: 2x6
    Condition: Extensive Rot and not connected to south wall

Secondary Elements:
  Fuel Tank: Steel frame, suspect lag attachment inadequate
**House # 133**

**Site Conditions:**
- Standing Water: No
- Subsidence: No

**Arctic Entry:** ADA-accessible ramp and new stairs

**Floor Diaphragm:**
- Condition: Did not go into interior of home
- Underside: Dry

**Visible Mold:**
- Exterior: Extensive mold on north facade
- Interior: Did not go into interior of home

**Wall Moisture Content:**
- Girders: 40%
- Base of Exterior Sheathing: 40%
- Exterior Sheathing 2’ up: 24% (South)
- Interior Sheathing 2’ up: 26% (South)

**Gutters:** No

**Window Damage:** Moderate
House #133

South Side:

Pilings:
  Type: 3 typical pilings
  Condition: Satisfactory
  Orientation: Strait
  Connections: \( \frac{1}{2} \)" Lag bolts

Glulam:
  Type: 5 1/8" x 13 1/2"
  Condition: Completely Deteriorated
  Deflection: 3/4"

Sheathing: Saturated and visible organic growth

North Side:

Pilings:
  Type: 3 typical pilings
  Condition: Satisfactory
  Orientation: Strait
  Connections: \( \frac{1}{2} \)" Lag bolts

Glulam:
  Type: 5 1/8" x 13 1/2"
  Condition: Completely Deteriorated
  Deflection: 3/4"

Sheathing: Saturated and visible organic growth

Common Elements:

Studs:
  Type: 2x6
  Condition: Extensive Rot