Observations of Insulation Products in Flood Damaged Homes

Hurricane Harvey - Sept 2017

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April 2018

*Funding for this project was provided by the North American Insulation Manufacturers Association

Executive Summary

Background and Goals: Following Hurricane Harvey, SPEER and Burgess Construction Consultants conducted a field analysis to collect and analyze data on the condition of various types of insulation in flood-damaged houses. The goals of the project were:

1) To observe and analyze the absorption, retention, and spread or wicking of moisture by insulation products;
2) To document the effects of flood water that had been absorbed and retained by insulation products on the drying, cleaning, and reconstruction of flooded homes, and;
3) To determine if current guidance on insulation to be used in wet floodproofing wall and flooring assemblies is in alignment with our findings.

This report is a summary of field observations of insulation products exposed to flood waters resulting from Hurricane Harvey that delivered catastrophic rainfall to the Houston metropolitan area from August 17 to September 2, 2017. The report was created to bring awareness to the issue of how insulation products are affected by flooding and is not a comprehensive scientific study of this issue. The observations included in this report highlight possible deficiencies in current guidance and/or code requirements for building in flood prone areas and repairing buildings that have been subjected to flood waters. Furthermore, this information should be considered when designing laboratory and real-world research on the effects of floodwaters on buildings and when developing guidance or building code requirements intended to minimize damage to buildings subject to flooding.

Methodology: To facilitate consistent data collection, the team developed an electronic data collection form prior to performing fieldwork. At each home, team members collected as much information as possible, took photographs of insulation, wall and subfloor systems, any microbial growth, and any other conditions of note. Samples of insulation were collected, labeled and placed in plastic bags for transport to the Home Innovation Research Laboratories to be analyzed for moisture content and the time required for substantial drying under controlled conditions.

The team requested permission from homeowners or contractors before inspecting houses and collecting samples. The contractors or homeowners were assured that their privacy would be respected and that no identifying information about the houses would be made public.

The team visited ten (10) homes and collected eight (8) insulation samples:

- Four (4) homes where the team had access to the entire home and was able to collect insulation samples directly from walls or under floors.
- Two (2) elevated homes where floodwaters only reached the subfloor framing levels. Homeowners or contractors had already removed the insulation. At these homes, the team was able to inspect the garage walls and subfloor above crawl spaces. At one of these homes, the team collected a sample of open cell SPF that had been removed, enclosed in plastic bags and placed at the curb for collection.
- One (1) elevated home under construction where the stem wall was built with flood openings where the floodwaters did not reach the subfloor insulation.
- One (1) home where the contractor had removed rock wool insulation from the interior walls prior to the team's arrival on site.

- One (1) home where the owner had removed the open cell SPF prior to the team's arrival, had enclosed the insulation in plastic bags, and placed them at the curb for collection. The team collected two samples of open cell SPF at this site.
- The team also collected a sample of rock wool insulation from a house they were not able to gain access for inspection.

The eight (8) insulation samples included:

- Three (3) samples of open cell SPF
- One (1) sample of a fiber glass batt
- One (1) sample of closed cell SPF
- Two (2) samples of rock wool
- One (1) sample containing separate pieces of open cell and closed cell SPF

Insulation Conditions and Associated Issues

Wicking of Moisture: It is commonly believed in the construction industry that all moisture permeable insulation will wick moisture from sections of the insulation that has been wetted to the dry areas that were not immersed in water. This study did not find evidence of wicking in excess of 1 to 2 inches through any type of insulation. It is likely that the wicking is less than one to two inches, but given the difficulty of accurately measuring wet insulation that has been removed from framing cavities, we feel confident in stating that wicking did not exceed one to two inches.

Wiring: Building codes require that wiring and fixtures that have been submerged in floodwaters be replaced. The contractor performing remediation on the study house insulated with closed cell SPF in wall cavities said he did not intend to replace the wiring even though it had been submerged because of the cost. Removal of mineral fiber insulation has no impact on wiring. The removal of either open cell or closed cell spray polyurethane foam (SPF) on the other hand is much more difficult, especially with closed cell SPF. It is common practice to use a knife or reciprocating saw to separate the foam from the sides of wall studs/framing members to allow easier removal. In cases where the wiring is intended to be re-used, the removal of open cell or closed cell SPF using sharp tools that may cause damage to the wiring and create fire or other safety hazards must be avoided.

Drying of Assembly: Our observations show that moisture permeable insulation left in place will not dry measurably over time frames as long as two to three weeks, depending on climate conditions. This is also true of the structural components of wall assemblies; those left enclosed did not dry and showed evidence of microbial growth and, in some cases, structural deterioration. Wall assemblies that had the gypsum board and insulation removed within a few days after the floodwaters receded were dry and had less microbial growth and structural damage such as deteriorated exterior sheathing.

Performance of Closed Cell SPF: Closed cell SPF does not absorb significant amounts of moisture and it performs as an effective air and moisture barrier. This barrier does not allow the wall sheathing and framing to dry to the inside while the wall cladding and house wrap inhibit drying to the outside. The contractor on the house inspected with closed cell SPF had been trying to dry the house using fans and

dehumidifiers for two weeks or more and the wall sheathing behind the closed cell SPF was still saturated, deteriorating and showed signs of microbial growth.

Recommendations

Immediate Clean Out of Flooded Buildings: Our observations indicate that the most important thing homeowners and remediation contractors can do to maintain the integrity of structural systems and prevent microbial growth is to remove wet floor coverings, gypsum board, insulation and other materials as soon after the flood waters recede as possible. After removal, flooded areas should be cleaned with water or water and a microbial control product and left open long enough to dry thoroughly.

Guidance for Closed Cell spray Polyurethane Foam: FEMA Technical Bulletin 2 *Flood Damage-Resistant Material Requirements* (August 2008) recommends using closed cell or plastic foam insulation in portions of walls below the Base Flood Elevation. The justification for this appears to be that these materials are flood resistant and can be left to dry in place. SPEER observations in Houston support revision of FEMA and NFIP recommendations to include the use of mineral fiber insulation. Closed cell SPF and plastic foam insulation in walls and floors submerged in floodwaters can severely impede the drying process necessary for remediation and may retain harmful contaminants in those assemblies. It is more cost effective and efficient to remove and replace mineral fiber insulation than to follow the current recommendations.

Observations of Insulation Products in Flood Damaged Homes, Hurricane Harvey

Background & Introduction: Following the record flooding caused by Hurricane Harvey in August of 2017, SPEER and Burgess Construction Consultants conducted a field analysis in the Houston area of the impacts of flooding on wall and floor assemblies containing residential insulation products. The scope of the study included inspection of homes with mineral fiber (fiberglass and rock wool), SPF (open and closed cell), and cellulose insulation in walls and floors that had been inundated with floodwaters (Note: No samples of cellulose insulation were observed during the study). The goal of these inspections was to document the condition and impacts of insulation products in the following areas:

1) The absorption, retention, and spread (wicking) of water by insulation products;
2) The effects of water absorbed and retained by insulation products on the drying, cleaning and reconstruction of flooded buildings, and;
3) To determine if current guidance on insulation use in wet floodproofing wall and flooring systems aligns with the findings from the study.

FEMA Technical Bulletin 2/August: 2008 Flood Damage-Resistant Materials Requirements

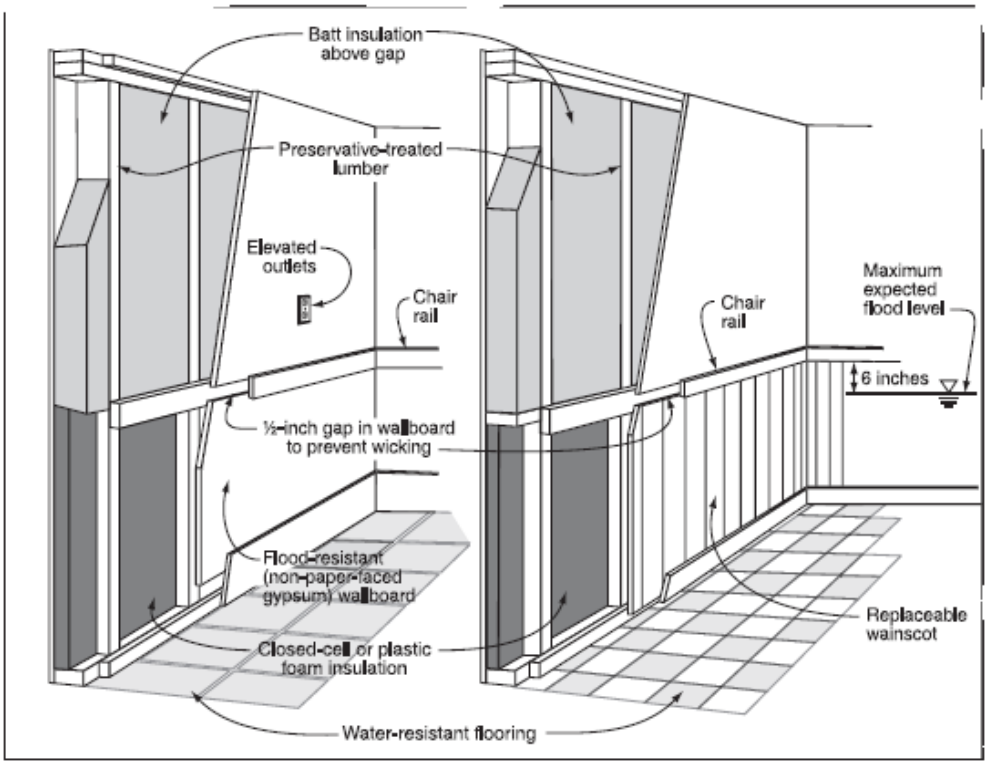

Figure 4. Partial wet floodproofing technique using flood damage-resistant materials for finished wall construction.

Methodology: The study targeted communities with high levels of flooding and homes with different types of insulation: fiberglass, SPF, and cellulose (Note: No samples of cellulose insulation were observed during the study). This led the team of focus on the Meyerland neighborhood, areas along Buffalo Bayou, and the Cypress-Barker neighborhood in western Houston.

Prior to the site inspections, the team developed an electronic checklist to ensure consistency in the data collection. The data collection form was completed for each house where the team had access to inspect the house. Team members took pictures of conditions as specified in the data collection form and any other conditions thought to be important. A sample data collection form is included as Appendix B.

The team collected samples of insulation. Each sample was placed in a sealed plastic bag and transported to the Home Innovation Research Laboratory. The lab analyzed each of the samples for moisture content and time required for substantial drying under controlled conditions.

Team members obtained permission from homeowners or contractors to inspect the houses and collect insulation samples. They were assured that their privacy would be protected and no identifying information would be revealed as part of this study. All the homeowners and contractors we interacted with permitted access to their houses for the purpose of gathering information on flood remediation.

Findings and Results: Ten (10) homes were visited during the course of the study. Complete assessments were performed on four (4) homes where flooding reached living spaces. In two additional houses, the team was able to access the garage and to collect data, take photos and samples of insulation from garage walls or under floors or insulation that had been removed from the walls or floors. SPEER also collected a sample of rock wool loose-fill insulation that had been gathered from the curb in front of a house that was not accessible.

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Summary table of houses, insulation samples and high-level information

House ID	Insulation Sample ID	Insulation Type	Insulation Location	Floodwater Max Height	Floodwater Duration	Microbial Growth	Framing/Sheathing Material & Condition
1	101	mix oc SPF and cc SPF	under subfloor	unknown	unknown	none detected	plywood - dry and intact
2	102	rock wool loose- fill	Wall	unknown	unknown	not inspected	not inspected
3	103,104	oc SPF	under subfloor	unknown	unknown	not Inspected	not Inspected
4	105	fiber glass batt	Interior wall	62”	14 days	Extensive, throughout house	impregnated fiberboard – wet and deteriorated
5	106	cc SPF	Interior Wall	27”	7 days	moderate to extensive in wall framing and sheathing	exterior gypsum board – wet and deteriorated
6	107	rock wool batt	Interior Wall	40”	21 days	Moderate in wall framing and sheathing	T1-11 – wet and intact
7	108	oc SPF	Garage wall	16”	5 days	none detected	OSB – wet and intact
8	N/A	oc SPF	under subfloor	32”	Did not reach insulation	not inspected	not inspected
9	N/A	fiber glass batt	Garage wall and under subfloor	unknown	unknown	none detected	plywood dry and intact
10	N/A	rock wool batt	Interior wall	unknown	unknown	none detected	exterior gypsum board removed, framing dry and intact

Notes: None of the homes assessed contained cellulose insulation in areas exposed to flood waters. Sample 101 contained a very small amount of closed cell SPF used as seal between the foundation and the garage sill plate insulation. For detailed description of each house, see Appendix A.

Insulation Condition & Associated Issues

Wiring interactions: One area of concern was the integrity of electrical wiring after removal of insulation. Building codes require the replacement of outlets and wiring that have been submerged. Standard practice after flooding is to remove gypsum board and insulation to a level four feet above the floor (to the horizontal gypsum board joint.). Wiring for wall outlets is placed about 16-18 inches above the floor line. If the wiring is above the water line, it can be reused. Mineral fiber insulation is easy to remove and does not affect wiring or outlets. Both open cell and closed cell SPF are much more difficult to remove. Use of a knife, reciprocating saw or sharp tools to separate the foam from framing members creates a risk of cutting the wiring protective coating and exposing the conductors, creating a potential fire hazard or short circuit.

Drying of Assembly: Insulation dries very slowly if left in place within the wall assembly. Observations indicated that insulation left in walls did not dry substantially even several weeks after the flood waters had receded. This appears to be true of all the materials that absorb water (mineral fiber and open cell SPF). This also applies to wall sheathing and subflooring; a free flow of air is needed to allow drying. In assemblies where the gypsum board and insulation were removed within a few days after the floodwaters receded, the framing and wall or floor sheathing materials dried quickly with little damage or mold growth. In the two houses observed where the insulation was still in the walls two weeks after the floodwaters were gone (houses 4 & 6), the insulation and sheathing was still saturated and microbial growth was substantial and spreading.

Wicking moisture: It is commonly assumed in the construction industry that saturated insulation will wick moisture from below the flood line up into areas that were not affected by the floodwaters. The team did not see any evidence of moisture wicking more than one to two inches occurring in any type of insulation.

Closed Cell Spray Foam Performance: Closed cell SPF did not appear to absorb significant amounts of water (6 grams of water in a ten inch by ten inch square two inches thick) but was very difficult to remove. At the house the team observed with closed cell SPF (house #5), the insulation was dry but the sheathing between the insulation and exterior brick façade was saturated and deteriorating. The contractor had been running fans and dehumidifiers to dry the house for at least two weeks but the sheathing had not dried. The contractor told us that his only option was to cut the closed cell SPF out by hand, remove the existing sheathing from the inside and cut and piece new sheathing between the framing members from inside the house. This is a time consuming and expensive task and is unlikely to produce an acceptable outcome. The only other option is to remove the brick cladding and replace the sheathing from the outside. He is planning to leave the current electrical wiring in place as he removes the closed cell spray foam insulation, but this may prove to be too difficult to do. Note: In SPEER's ongoing work with building officials, contractors and homeowners, the issue of removal of SPF resulting in the unintended removal of continuous insulation board and other types of sheathing has come up several times. There are no known acceptable methods of replacing sheathing without removing the exterior veneer/cladding.

Insulation Moisture Retention: Samples of insulation were collected, sealed in plastic bags, and sent to the Home Innovation Research Laboratory for weighing, drying, and analysis of moisture content over time.

The laboratory findings show that closed cell SPF retains the least amount of moisture and dries most quickly. (Note: Insulation sample 101 was an open cell SPF sample with a small amount of closed cell SPF mixed in that did not contain any noticeable moisture when collected at the house.)

Open cell SPF, fiberglass batts, and rock wool all absorbed significant amounts of moisture. The fiberglass batts absorbed over three times the weight of the dry insulation (330% moisture content by weight) while the rock wool absorbed almost half the dry weight (42%). The samples of open cell SPF absorbed over 300 times the insulation dry weight (3040%) for one sample and 130 times (1320%) for the other. The fiberglass and rock wool had dried to 0% moisture by weight within eight days and four days respectively. After eight days, the open cell SPF samples retained about one third of the initial moisture (960% and 380%). These samples did not reach 0% moisture content for three weeks. In all cases it is critical to remove the wet insulation from cavities as soon as possible because the moisture it retains can contribute to microbial growth and/or deterioration of the surrounding building materials.

Summary table shows the progress of drying in controlled conditions over time.

Insulation Sample Percent Moisture Content
(by weight)

	Days Drying	0	1	4	5	6	7	8	13	18	21	22	27
101	**ocSPF***	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
102	**RW batt**	6.9	3.4	3.4	3.4	3.4	3.4	3.4	3.4	0.0	0.0	0.0	0.0
103	**ocSPF**	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104	**ocSPF**	3040	2660	1840	1620	1420	1160	960	360	129	20.0	0.0	0.0
105	**FG batt**	330	285	172	132	93.6	53.2	25.5	0.0	0.0	0.0	0.0	0.0
106	**ccSPF**	5.7	1.9	1.9	1.9	1.9	1.9	1.9	0.0	0.0	0.0	0.0	0.0
107	**RW batt**	42.0	18.8	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108	**ocSPF**	1320	1180	823	707	603	480	380	103	29.6	6.7	3.3	0.0

* NOTE: This sample had a very small amount of ccSPF in the sample

MC % = moisture content percentage by weight - ((wet weight - dry weight) / dry weight) x 100

Moisture Content Analysis Methodology: On or about October 4, 2017 Home Innovation Research Labs (HIRL) received a shipment containing eight (8) insulation samples from Burgess Construction Consultants. The materials were packaged in watertight plastic bags and labeled with a number corresponding to a list of addresses contained in the shipping box. HIRL staff carefully removed the samples from the plastic bags and placed them in screen bags to allow the samples to air dry. The screen bags were labeled with the same numbers as the watertight plastic bags. The samples were stored in a conditioned room with an ambient environment controlled at 75 ± 5°F and 25 ± 5% relative humidity. An initial weight measurement of each sample was taken on October 5. Weight was measured and recorded at approximately one-day intervals during the workweek between October 5 and October 31. HIRL staff stopped taking weight measurements on October 31 when the loss rate due to drying was 0.25% or lower for each sample, indicating that the samples had stabilized. The percent moisture by weight of each sample was calculated and reported.

Recommendations for Homeowner/Contractor Outreach and Education

Open Cavities Immediately: FEMA currently recommends that homeowners or contractors remove flood-damaged insulation, gypsum board and other components as quickly as possible and allow the exposed framing and sheathing time to dry before reconstruction. Our observations support this recommendation and we suggest that this may be the most important thing home or building owners can do after a flood. We recommend that FEMA work with local officials, disaster relief organizations and others to make the FEMA *Air Out, Move Out, Tear Out, Clean Out and Dry Out* factsheet and recommendations more widely available to the public and contractors.

Elevate Homes. Based on conversations with the owners and contractors we met, a large number of the affected homes have flooded several times. Often, the floodwaters were so intense that they undermined foundations or pushed the brick cladding off the brick ledge. The newer homes, which were elevated and built with flood openings or break-away walls, suffered relatively minimal damage, if any, usually only flooding as high as the lower floor framing. There have been three “five-hundred year” floods in the Houston area within the past three years. As more of these homes are deemed to have sustained “substantial” damage and are required to be rebuilt to Flood Hazard Standards the methods and materials

for rebuilding will be very important. SPEER recommends that FEMA work with the insurance industry, building officials and the public to ensure that homeowners are aware of their home's flood hazard status and requirements for reconstruction after disasters.

Recommendation for Revising FEMA Technical Bulletin

Revise FEMA Guidance for Wet Floodproofing Walls: FEMA Technical Bulletin 2 / August 2008 recommends using closed cell or plastic foam[1] {board} insulation in the portions of walls below the Base Flood Elevation (BFE) as insulation in wet floodproofing applications for homes where elevation above BFE is not required. The justification for this appears to be that these materials are thought to be flood resistant and can be left to dry in place. Our observations in Houston contradict some of these recommendations.

1) Our observations indicate that closed cell SPF or plastic foam left in place, as recommended in the wet-proofing guidelines, does not allow wall sheathing and the framing enclosed by the left-in-place insulation to dry.
2) Floodwaters often contain petroleum-based residue, fecal coliform from animal waste, and other contaminants that need to be removed for health and safety reasons. The current wet-proofing wall recommendations allow for cleaning the exposed surfaces, but do not consider the need to clean the sheathing, and other components of the wall enclosed by closed cell or plastic foam {board} insulation. Cleaning will not remove petroleum-based contaminants from SPF or plastic foam materials.

To remedy these concerns, SPEER recommends that FEMA consider changing the wet floodproofing recommendations to support using mineral fiber insulation in wet floodproofing. When flooding occurs, the mineral fiber insulation can be removed and replaced with new. Removal of the insulation will allow cleaning and drying throughout the wall. Replacing with new mineral fiber insulation will eliminate the possibility that replacing the insulation with the previously removed and cleaned insulation is introducing contaminants such as petroleum based residue or fecal coliform into the indoor environment.

To ensure that the wall sheathing and interior side of the cladding/veneer can dry completely, SPEER also recommends the use of rain screen exterior wall systems to create a drainage plane and allow airflow for drying.

[1] FEMA regulations use the term "closed cell or plastic foam insulation" but do not define "plastic foam." Plastic foam includes many types of material including spray foam (open and closed cell) and preformed board type products. For the purposes of this report, SPEER assumed the FEMA regulations reference to "plastic foam insulation" materials means ones that are impermeable to water penetration (e.g. closed cell spray foam and EPS/XPS foam board).

Appendix A: Field Survey Data

House #1: Insulation had been removed from the garage and subfloor of the house and placed in sealed plastic bags that were deposited on the curb. Inspection of the garage wall and floor framing, wall sheathing and subflooring showed they were dry with no visible signs of microbial growth. A sample of open cell SPF that did not appear to contain any moisture was collected from insulation contained in bags at the curb.

Insulation type	Insulation location	Floodwater max height	Floodwater duration	Microbial growth	Sheathing-framing condition
Open cell SPF with small amount of closed cell SPF	Under floor	Unknown	Unknown	Not visible	Dry and intact – OSB and plywood

Note how OC SPF appears to have been applied from above leaving air gap between top of foam and bottom of subfloor sheathing in pictures

House #2: The team collected a sample of saturated rock wool loose-fill insulation at the curb in front of the house. The team was not able to gain access to this home. The team collected a sample because they assumed there would be limited opportunities to collect rock wool samples.

Insufficient information was available on this home to create a table. No pictures taken.

House #3: Homeowner or contractor had removed open cell SPF due to flooding. The team collected two saturated samples of open cell SPF from this house. Samples were collected from bagged insulation at the curb. Team was not able to gain access to this home.

Insufficient information to create table. No pictures taken

House #4: At this house, the team collected a sample of fiberglass batt insulation that was saturated. The sample was collected from a wall. There did not appear to be any wicking of moisture from flooded areas into areas that were not flooded. The floodwaters reached a height of 62 inches on this house. The gypsum board was being removed while the team was there. There was extensive mold growth throughout the house, including on the ceiling. Insulation and gypsum board had not been removed in a timely manner. The impregnated fiber board sheathing was also saturated and decomposing. This house flooded three times in the previous three years and the contractor on site said the owner was waiting for the insurance appraiser to recommend demolition.

Insulation type	Insulation location	Floodwater max height	Floodwater duration	Microbial growth	Sheathing-framing condition
Fiber glass	Interior walls	62”	14 days	Extensive throughout house in walls and on surfaces	Saturated and deteriorating, impregnated fiber board

House #5: The team collected a sample of closed cell SPF from within a wall in a house where the remediation contractor had been running fans and dehumidifiers for at least two weeks in an attempt to dry the framing and sheathing. The insulation was approximately two inches thick, sprayed adjacent to exterior gypsum sheathing over brick cladding. There was an inconsistent air space between the exterior of the gypsum board and the interior side of the brick. The foam did not contain any significant amount of moisture (6 grams moisture in a ten inch by ten-inch sample two inches thick). The gypsum was saturated and decomposing after two weeks of unsuccessful attempts to dry the house. There was significant microbial growth on the framing and sheathing. The floodwaters reached a level about 27 inches above floor grade on this house.

Insulation type	Insulation location	Floodwater max height	Floodwater duration	Microbial growth	Sheathing-framing condition
Closed cell SPF	Interior walls	27”	7 days	Moderate to extensive on wall sheathing and framing	Saturated and deteriorating exterior gypsum

House #6: This house was in the early stages of flooring, gypsum board and insulation removal. The team collected a sample of insulation from a wall the contractor deconstructed specifically for us to sample. The insulation was saturated, but there were no signs of wicking. The T1-11 sheathing was wet and had moderate microbial growth, as did the framing. This house was approximately 100 yards from Buffalo Bayou and suffered extensive flooding to a height of approximately 40 inches above floor grade. Because the flooding was due to rising bayou waters and because the water remained in the home for at least a week, there is a possibility contaminants such as fecal coliform and petroleum residue have been absorbed into the structure of the house. Note the picture below of the insulation batt showing the saturated condition of the batt at and below the water line and the dry condition of the batt above the water line.

Insulation type	Insulation location	Floodwater max height	Floodwater duration	Microbial growth	Sheathing-framing condition
Rock wool Batt	Interior walls	40”	21 days	Moderate on wall framing and sheathing	Wet and intact T1-11

Note transition from wet to dry indicating lack of wicking

House #7: This house is in the Cypress/Barker area of Houston. The carpet, gypsum board and most of the insulation had been removed. The team was able to collect a sample of wet open cell SPF from the garage wall. The framing and sheathing were wet with no signs of microbial growth. The house had flooded to a level of about 16 inches above garage floor grade. The floodwaters remained in the house for about five days. Gypsum board and insulation were being removed to a level of 24 inches above floor height.

Insulation type	Insulation location	Floodwater max height	Floodwater duration	Microbial growth	Sheathing-framing condition
Open cell SPF	Garage wall	16”	5 days	Not visible	Wet and intact – OSB

House #8: This was a new house under construction. It was notable because the water line on the house was about 30” above grade. Because the house was elevated and built with flood openings in the stem wall, the floodwater flowed through, only wetting the moisture proofing in the crawl space and the garage walls that had been repaired when the team inspected the house.

No pictures taken. Not sufficient information to create table.

House #9: The homeowner had removed fiberglass batts from the subfloor and garage walls of this house before the team arrived. The framing, wall sheathing and subfloor sheathing were dry and intact with no signs of microbial activity. This new house is elevated above the base flood elevation. The floodwaters, apparently, reached the subfloor insulation but did not damage the finished floor.

Insulation type	Insulation location	Floodwater max height	Floodwater duration	Microbial growth	Sheathing-framing condition
Fiber glass batts	Garage wall/subfloor	Unknown	Unknown	Not visible	Dry and intact –plywood

House 10: This house is adjacent to house #5 and similar in construction to that house except that in this house rock wool insulation was used in the walls instead of CC SPF. The same contractor was remediating both houses and had removed the rock wool insulation before the team arrived. The framing was dry and showed no signs of microbial growth. However, the exterior gypsum board sheathing had sustained water damage and been removed.

Insulation type	Insulation location	Floodwater max height	Floodwater duration	Microbial growth	Sheathing-framing condition
Rock wool batts	interior walls	approximately 27”	7 days	not visible	framing dry and intact, sheathing removed

Appendix B Data Collection Form

Electrical
Electrical Photo
Interior Finish
Framing below flood line
Framing above flood line
Framing Microbial Growth Photo 1
Sheathing below flood line
Sheathing above flood line
Sheathing Microbial Growth Photo 1
10"x10" insulation sample taken
Insulation Weight
Sheathing % at bottom plate
Framing % at bottom plate
Sheathing % at 12"
Framing % at 12"
Sheathing % at 24"
Framing % at 24"
Sheathing % at 36"
Framining % at 36"
Sheathing % at 48"
Framing % at 48"
General Comments