Spray Polyurethane Foam / Termite Detection Demonstration Project (July – August 2019)

Introduction

The Demonstration Project described in this report was an attempt to gather information on the utility of identifying subterranean termite infestations in or on structural components covered with Spray Polyurethane Foam (SPF) insulation. The project was conducted in a crawlspace with an active infestation of the dark southeastern subterranean termite, *Reticultermes virginicus*. The crawlspace had hollow-block foundation walls and piers with wood framing above that which served as the support for the rooms on the first floor of the structure. Initial inspections were conducted on July 16, 2019 using visual search, moisture meters, infrared cameras, a laser thermometer and a microwave motion detector. Five inspectors, identified herein by number (1-5) each used a different approach. Inspector #1 conducted a visual search in conjunction with a moisture meter; #2 used visual inspection and an infrared camera; #3 used visual inspection, a moisture meter and motion detector; #4, moisture meter, borescope and infrared camera; and #5 used visual inspection, moisture meters and an infrared thermometer. Inspectors were given one hour to examine the crawlspace and place laminated cards (red arrow) at locations where they identified termite activity. The distribution of red arrows was recorded by photography after each inspection. Inspectors then agreed to 6 locations where SPF insulation would be applied to the hollow-block foundation wall (two locations) and wooden structural members (four locations) in the crawlspace. The application of SPF at each Location included half of the designated area covered using closed-cell (2-3 inches thick) and the other half open-cell (4-6 inches thick) SPF. The following day, 17 July, the crawlspace was for a second time inspected by the same teams using the same equipment and the number and distribution of red arrows recorded for comparison with the previous inspections. One month after SPF application, 15 August, an additional inspection was conducted by all parties after which destructive sampling was conducted to verify the presence of live termites at all Locations examined in this demonstration project.

Building: River Basin Center, School of Ecology, University of Georgia, Athens, GA 30602
Areas Inspected: Crawlspace in the north east corner of the structure
Site Description: The crawlspace measured 20X20X20X10-ft and was installed during a renovation of the building in 1999 (Figure 1). The crawlspace was defined by hollow block walls approximately 7-ft high with wood framing for the floor with four hollow block piers and one metal pole as supports for the floor in the center of the space. A vapor barrier was placed over the soil floor of the crawlspace on July15, 2019.

Description of equipment used by inspector (number) and equipment (type, model):
All inspectors had at least 20 years' experience conducting termite inspections. The firm that applied SPF has been in business for 5 years and has a A+ BBB rating.

#1, Ryobi, E49MM01 resistance (surface with digital readout in %)) and Protimeter Mini (BLD2001) a pin-type (subsurface with light-up scale in 1% increments from 6-30) moisture meters

#2, Infrared camera, FLIR E6

#3, Termatrac T3i All Sensor 3-n-1 unit with the following functions, Radar Technology confirms movement, Moisture sensors both Direct & Relative using Omni-Directional Technology (digital readout in %) and Thermal Sensor showing changes in surface temperature.

#4, Infrared camera, Protec IT 100; A moisture meter, Protimeter moisture meter system-logging MMS2 (digital readout in %) and a XLVU Videoprobe (a flexible borescope), Baker Hughes Co.

#5, Infrared thermometer, General IRT207, and two moisture meters; Tramex moisture encounter resistance (surface, range in 1% increments on a graph from 10-20%) and Delmhorst Instrument Co. PC-3 pin-type (subsurface, range in 2% increments that light-up display measuring from 8-30%).

Initial Inspection notes, 16 July:
The wooden structural members - joist header, sill plate, joists and cross beams - in the crawlspace provided numerous locations where visual evidence of subterranean termite infestation was clear and obvious. There also were 10 areas with subterranean termite shelter tubes on the exterior surface of the concrete block foundation.

All 5 inspectors collectively placed 38 red arrows in the crawlspace during the initial inspection in the area adjacent to the entryway along 40 feet of foundation wall from the southeast corner to the northwest corner of the crawlspace (Locations 0, 15, 20, 30 and 35 38). The range of arrows placed per inspector was 3 to 14 (Table 2).

Surface temperatures on all substrates – block or wood – did not vary more than 0.9 degrees Celsius (1.6 degrees Fahrenheit) between any of the surfaces in the crawlspace with no pattern related to signs of termite activity. The Flir IR camera identified 1 area of termite activity on wood (Location 15) (Photograph 2) and 2 other termite-activity areas were associated with shelter tubes at Locations 0 & 40.

The moisture readings obtained on the wooden floor joists, headers and sill plates indicated elevated moisture in all the wood in the crawlspace. Depending on the type of meter and location readings ranged from 18-30% wood moisture using resistance (surface) meters to 20-30% wood moisture using a meter with insertion pins (subsurface). The resistance/surface moisture meters provided readings of 20-50% when placed on the surface of the cinder block

foundation while one pin-type meter registered 100% on the block when pins were placed against the surface of that material.

The Termatrac T3i microwave motion detector identified notable movement in the shelter tubes at locations 0 and 20 as well as in the beams and sill plate at locations 5 and 15 but not 25 or 30. No live termites were observed at any location despite destructively sampling a 1-2 inch section of shelter tube at locations 0, 20 and 40 (Location 40 was on the north wall but not indicated in Figure 1). There was no destructive sampling of any of the wood supports on this inspection.

SPF foam was applied to the shelter tubes at locations 0 and 20 and on the sill, joist header and beams at locations 5, 15, 25 and 30 (Photograph 1; Figure 1). Two types of SPF were applied at each location, closed cell SPF at 2-3 inches and open cell SPF at 6-8 inches thick.

Inspection notes after SPF application; 17 July:
The number of red arrows placed on the exposed wood by all 5 inspectors was 39 the day after SPF application (Table 2). None of the visual inspections provided evidence of termite activity on the SPF (Table 2). The only device that detected termites through the SPF was the Termatrac T3i microwave motion detector which identified 6 locations (red arrows placed) on the SPF (Table 2). The Termatrac T3i identified movement in shelter tubes at 5 areas including Locations 0 and 20 as well as the beams and sill plate at Locations 5, 15 and 30… but not 25 (Table 1 & 2).

Surface temperatures on the block wall and structural lumber varied by 1.9 degrees Celsius (3.6 ^{0}F) and on foam by 0.9 degrees Celsius with no pattern related to signs of termite activity (Table 1). There were no areas of termite activity identified by the IR cameras on SPF or exposed wood or block.

Moisture readings obtained on the foundation wall, floor joists, headers and sill wood provided the same range of values, by device, measured on inspections conducted the previous day, July 16 (Table 1). Moisture readings on the SPF surface with resistance meters was zero while the pin meters ranged from 2-4% on the surface but registered 0-8% when pins were inserted into either the open- or closed-cell foam. The Termatrac T3i measures of moisture on foam varied from 4-11% with no identifiable pattern related to areas of termite activity.

No live termites were observed at any location and the sections of shelter tubes at locations 0, 20 and 40 that were broken during the previous inspection, on day earlier, had not been repaired. There was no destructive sampling on this inspection.

Inspection notes one-month after SPF application; 15 August:
Inspections aimed at determining termite activity were not recorded during the August visit to the crawlspace due to time constraints and the assumption that those results would be similar to the previous two inspections. Initial visual inspections did not reveal signs of termite activity on the foam but as SPF removal progressed (Photograph 3) it was observed that one area of closed cell foam (at Location 5) on the interface of the sill plate and foundation wall showed signs of termite activity (Photograph 4). When SPF was removed from the block covering the shelter tubes at locations 0 and 20 there were live termites in the shelter tubes but no evidence of

termites leaving the shelter tubes and entering the foam. Termites did, however, tunnel into the foam on the beams, joist header and sill at locations 5 and 15 and but not areas 25 or 30 (Photograph 3). There were hundreds of live termites in the foam removed from the aforementioned areas and live termites also were observed in the sill and beams at areas 5 and 15 by destructive sampling and with the borescope (Photograph 5).

Surface temperatures on wood varied by 1.9 degrees Celsius and on foam 0.9 degrees Celsius with no pattern related to signs of termite activity (Table 1).

The range of moisture readings on wood were within the range of values from one month earlier for each of the different devices. The one exception was the Termatrac readings that were, across all locations, higher than in the previous month. The moisture readings on the block were essentially within the same range within a device but showed more variability compared to the previous month with the Termatrac T3i and Delmhorst being higher while the Tramex provided lower values. All devices recorded significantly higher wood moisture content in the joists and joist header that had been under the SPF except the Termatrac which provided lower wood moisture content in those areas (Table 1).

Moisture readings were taken on the area of visible termite activity in the SPF at location 15 and the only device that provided a different reading was the Termatrac T3i that showed 9-15% on the foam next to the area of visible activity and 17-23% on top of that location (Photograph 6).

In addition, we used a XLVU Videoprobe borescope to verify termite activity in the wood behind Loctions 5 and 15 as well as demonstrate that this device could also distinguish between infested and not-infested foam (Photograph 5).

Summary:

This SPF/termite-detection demonstration aimed to examine the ability of pest management professionals, experienced in termite inspections, to identify an active termite infestation in the same crawlspace before and after application of SPF insulation. The site was a crawlspace with a moisture problem as evidenced by the wood % moisture recorded with all moisture meters used by the inspectors (Table 1).

The results from the visual inspections included the obvious, intuitive, observation that visual inspection was prevented following application of SPF to either the wood or hollow cinderblock construction materials (Table 2). Visual inspections are subjective, and inevitability, grounded in the experience of the individual inspector and circumstances at the time and place of the inspection. This point is evident in the summary of the number of red arrows placed by each inspector on the first two inspection dates (Table 2). The number of points identified (with red arrows) using visual search between inspectors indicating evidence of termite activity clearly underscores the aforementioned subjectivity. The fact that three experienced termite inspectors went to the same crawlspace and identify three different number of ‘active locations’ indicates the experiential nature of reporting termite activity using visual inspection. The number of different locations identified by each inspector could have been a result of the fact that evidence of termite activity was widespread in that crawlspace (Photographs 1 & 2). The purpose of an

inspection is typically to justify an intervention and one inspector could have placed 3 arrows in an area (split hairs) where the next inspector would have placed 1 because those locations all indicated need for intervention within a section of sill or joist.

Temperature readings taken on the surfaces in the crawlspace displayed surprising similarity regardless of substrate with never more than a ±2 degrees Celsius difference between the wood, block or foam surface temperatures (Table 1). The fact that those temperature differences were within the range of detection for both IR cameras used in this demonstration and it is therefore not surprising those devices were not able to detect the presence of termites with or without a covering of SPF.

An equally interesting, but less obvious, result involved the moisture meters which provided a wide range of values at the same locations (Table 1) indicative of the relative nature of measurements taken by these instruments, depending on the device and technology used to translate electrical conductivity to a number representing percent moisture. All moisture meters with the exception of the Termatrac T3i were consistent with the surface-type meters generally providing no readings on the foam surface while the pin-type moisture meters provided low readings (0-8% moisture) when inserted into the foam. The Termatrac T3i moisture readings ranged from 4-11% the day after SPF application to 0-26% one month later (Table 1).

The conclusion we were able to reach, given the parameters that defined this demonstration project is that the devices employed by the participants were unable to identify any consistent indication of termite infestation on the wood or block and certainly not *through* the SPF insulation. Additional research under varying conditions should be conducted to see how these same or other termite detection devices perform. The Termatrac T3i was the only device to provide moisture readings (17-23%) on the area of closed cell SPF with visual confirmation of termite activity that was different from the surrounding foam (14-15%) (Photograph 6).

The Termatrac T3i using the microwave motion detector provided evidence of termite activity with and without the foam (Table 1). Confirmation of termite activity was confined to the last (August) inspections when destructive sampling was conducted. There were no live termites found during the July inspections when shelter tubes at Locations 0 & 20% were broken nor where those sections of shelter tube repaired (after SPF application) the following day. However, one month after SPF application (August inspection) thousands of termites were observed in the foam and in pieces of wood destructively sampled with a chisel and the borescope as well as in shelter tubes at Locations 0 & 20 (Photographs 3- 5). Destructive sampling using the borescope provided evidence that by drilling ¼-inch holes into SPF one can determine if termites are present (Photograph 5).

Postscript and Conclusions:

Renovation of the crawlspace used in this demonstration began on 6 September 2019. The sill plate, joist header, floor joists and flooring were removed from the foundation walls above the crawlspace entry and halfway down the length of the southern-most wall of the crawl. The renovation exposed the foundation wall behind the joist header and sill plate above Locations 0, and 5 mentioned in the report. An examination of the exposed elements of the foundation

provided substantial evidence that this infestation was initiated in the sill and joist headers in the southeast corner of the crawlspace. The amount of termite feeding activity observed in the joist header, sill and floor joists (Photograph Supplement 1) in that area displayed a pattern showing more wood removed from structural lumber closer to the SE corner of the crawlspace.

Subterranean termite structural infestations can be influenced by numerous factors including the construction practices employed – especially the elements of the foundation - as well as the surrounding landscape. This particular infestation was most likely exacerbated by the limited potential for air exchange in the crawlspace. This ~ 300 square-ft section of the structure contained two vents (12 X 8-in.), both in the north wall, coupled with no vapor barrier on the dirt floor of the space (it should be noted that during the September renovations it was discovered that there was a concrete slab floor in the crawlspace… under about 4 inches of soil). The higher- than-normal % wood moisture (The author defines 'normal' structural lumber % moisture to be 9-12% for this part of North Georgia) in the lumber of the crawlspace measured using moisture meters affirmed this point as did the observations of mold made by all inspectors conducting a visual search.

Inspection of any structure for subterranean termite activity is essentially a snap-shot in time of conditions observed during a site visit and the information recorded during this demonstration illustrates that point. The findings reported from a termite inspection are influenced by a number of factors including the type of equipment employed during the inspection. The variability reported within a single technique or piece of equipment between inspection dates shows that termite inspections can agree on the presence of termite activity although the data used to come to that conclusion might be disparate.

A visual inspection was sufficient to identify signs of a termite infestation and moisture management issues in this crawlspace. Verification of an active termite infestation and moisture problems required additional techniques and equipment. The industry standard of a visual inspection along with probing and sounding (i.e. destructive sampling) to verify an active infestation was not conducted until the third (August) inspection. The various moisture meters, indicated on the first and subsequent inspections, conditions of elevated wood moisture which would be conducive to maintaining a subterranean termite infestation. However, the moisture meters alone could not verify areas of active termite infestation. The technique employed (as per the protocol requirement of minimal disturbance) to verify termite activity during the first inspection – a visual inspection after exposing a small section of several of the numerous shelter tubes in this crawlspace - did not provide evidence of active termites. Subterranean termite activity was only confirmed during the August inspection using destructive sampling.

There were two non-destructive termite inspection technologies used during the inspections. The homogeneity of surface temperatures on all the substrates (wood, block or SPF) did not allow for a clear, definitive identification of termite activity using an IR camera. The Termatrac T3i microwave motion detector did indicate an active infestation at a number of Locations on all three inspections on all substrates examined – shelter tube on hollow block, structural wood, and SPF. Those indications of activity were verified during the August destructive sampling inspection.

The veracity of using visual inspection along with probing to identify an active subterranean termite structural infestation was confirmed by this demonstration project. The project also illustrated that SPF foam applied to structural lumber prevented a visual inspection of termite activity. The utility of moisture meters and IR cameras in identifying termite activity with or without SPF was not confirmed. The microwave motion detection device, Termatrac T3i, demonstrated the ability to detect termite activity in structural lumber with and without a covering of SPF. There are, however, practical limitations to conducting a termite inspection using the Termatrac T3i because it can detect motion in a relatively small (4 inches squared) area. Restricting the collection of termite inspection data to the scale of 4 inches^2 would require hours to complete a full inspection of the 300 ft^2 crawlspace used in this demonstration. The utility of using a device with such a small inspection 'window' complicates conducting a full termite inspection due, in part, to the increased time spent on site.

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Figure 1. Diagram of the crawlspace from the building floor plan with blue lines delimiting the interior foundation walls that define the crawl, green lines approximate distances (in feet) of the crawlspace foundation and the red line indicates the location of doorway providing access to the crawlspace. The Location numbers discussed in the report are posted in white boxes in red font with Locations O and 20 on the hollow block wall in the south east and southwest corners, respectively, and Locations 5, 15, 25, and 30 on the joists and joist headers on the south and west walls, respectively.

Photograph 1. Images of the locations discussed in the report where SPF was applied.
A. Locations 0 (not identified with a number; in the corner) and 5.
B. Locations 15, 20, 25, 30.

A.

B.

Photograph 2. Image of the IR camera screen (Flir E6) indicating an area determined to show termite activity during the first inspection (July, 17) and a visual image of the same area indicated by the red box (right).

Photograph 3. Images of termite activity in the SPF observed during the August inspection from the joists and joist header by Location 5.

Picture 4. Images of the area in the SPF at Location 5 that provided visible evidence of termite activity on surface of SPF… left (outlined by the red box) and that same area exposed during foam removal.

Photograph 5. Images from the borescope showing SPF without (left) and with (right) termite activity.

Photograph 6. Image of the Termatrac T3i percent moisture readings on closed-cell foam at Location 5 on the block in an area with (left) and without (right) termite activity.

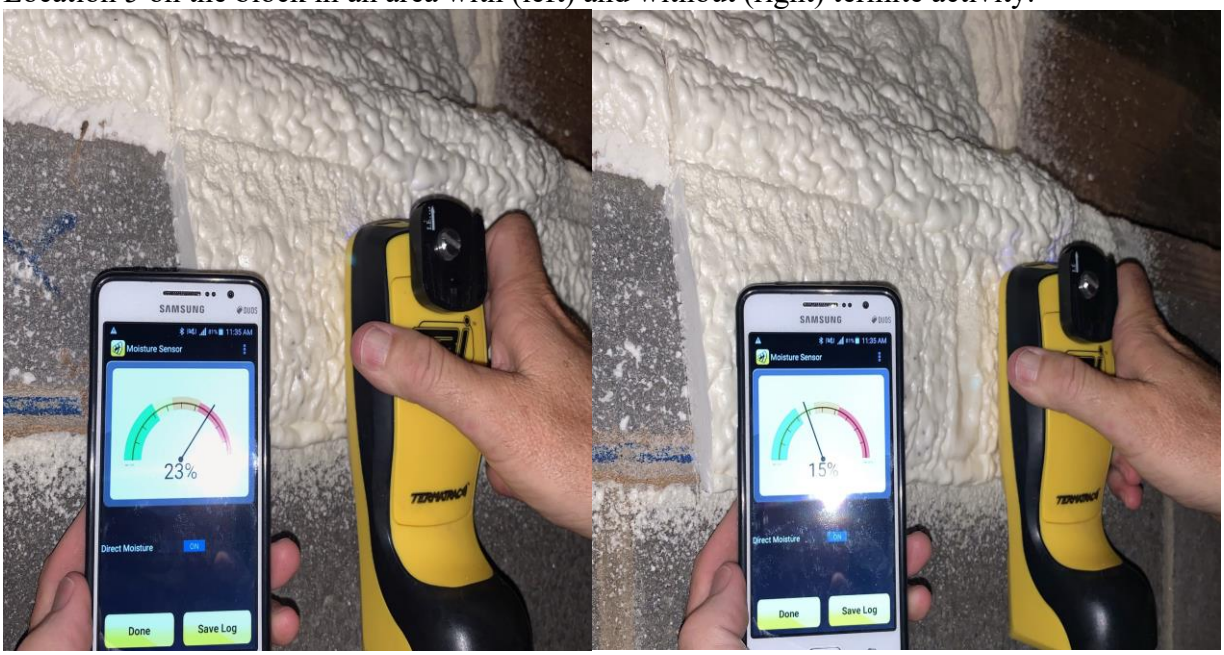

Table 1. The record of data collected in the crawlspace by date, instrument and location. A single number indicates the 2-3 readings within 1-ft^2 were consistent while a range is a record of the high and low reading for that instrument at that location. NA indicates "Not Applicable".

A. Readings taken July 16, 2019 prior to application of foam.

	Location Zero (on block)		**Location 5 (on wood beam)**		**Location 5 (on wood sill)**	
Meter type	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**
Delmhorst	NA	26	NA	20	NA	20
Protimeter	NA	30	NA	20	NA	24
Protimeter 2	NA	100	NA	18-20	NA	25-30
Tramex	NA	20+	NA	20+	NA	20+
Ryobi	NA	50	NA	30	NA	22
Termatrac T3i	NA	25-26	NA	19	NA	25
Laser temp ºC	NA	27.2	NA	26.6	NA	26.5
Termatrac T3i motion detector	Termatrac found movement on tube but no live termites seen in small section of broken tube		Termatrac found movement but no live termites seen, no destructive sampling		Termatrac found movement but no live termites seen, no destructive sampling	

	Location 20 (on block)		**Location 15 (on wood beam)**		**Location 15 (on wood sill)**	
Meter type	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**
Delmhorst	NA	20	NA	20	NA	20
Protimeter	NA	17	NA	22	NA	24
Protimeter 2	NA	100	NA	18-20	NA	25-30
Tramex	NA	20+	NA	20+	NA	20+
Ryobi	NA	33	NA	26	NA	34
Termatrac T3i	NA	25	NA	18	NA	24
Laser temp ºC	NA	26.3	NA	26.8	NA	26.4
Termatrac T3i motion detector	Termatrac found movement on tube but no live termites seen in small section of broken tube		Termatrac found movement but no live termites seen, no destructive sampling		Termatrac found movement but no live termites seen, no destructive sampling	

B. Readings taken July 17, 2019 one day after application of foam.

	Location Zero (on block)		**Location 5 (on wood beam)**		**Location 5 (on wood sill)**	
Meter type	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**
Delmhorst	0	26	0	20	0	20
Protimeter	1	100	2-4	19-22	0-2	24
Protimeter 2	4-6	68	4-6	18-20	4-6	17-20
tramex	0	20+	0	20+	0	20+
Ryobi	0	50	0	30	0	22
Termatrac T3i	4-11	25-26	4-11	19	4-11	25
Laser temp ºC	26.7	25.9	26.4	26.8	26.5	26.4
Termatrac T3i motion detection	Termatrac found movement on tube but no live termites seen in small section of broken tube		Termatrac found movement but no live termites seen, no destructive sampling		Termatrac found movement but no live termites seen, no destructive sampling	

	Location 20 (on block)		**Location 15 (on wood beam)**		**Location 15 (on wood sill)**	
Meter type	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**
Delmhorst	0	20	0	20	0	20
Protimeter	3-6	17	3-6	22	3-6	24
Protimeter 2	4	100	4-8	18	4-8	25-30
tramex	0	20+	0	20+	0	20+
Ryobi	0	33	0	26	0	34
Termatrac T3i	4-11	25	4-11	18	4-11	24
Laser temp ºC	26.5	26.4	26.5	26.5	26.4	26.5
Termatrac T3i motion detection	Termatrac found movement on tube but no live termites seen in small section of broken tube		Termatrac found movement but no live termites seen, no destructive sampling		Termatrac found movement but no live termites seen, no destructive sampling	

C. Readings taken August 15, 2019 one month after application of foam prior to foam removal.

	Location Zero (on block)		**Location 5 (on wood beam)**		**Location 5 (on wood sill)**	
Meter type	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**
Delmhorst	0	30+	0	20	0	24
Protimeter	0	14-17	2	20	0	24
tramex	0	17.5	0	20+	0	20+
Ryobi	8-16	33	12	26	14	34
Termatrac T3i	14-20	30+	7-26	30+	12-20	30+
Laser temp ºC	26.5-27	26.7	27.8	28.2	27.1	27.4
Termatrac T3i motion detector	Termatrac found movement through foam and on tube. Live termites seen during destructive sampling		Termatrac found movement through foam. Live termites seen during destructive sampling		Termatrac found movement through foam. Live termites seen during destructive sampling	

	Location 20 (on block)		**Location 15 (on wood beam)**		**Location 15 (on wood sill)**	
Meter type	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**	**On SPF**	**w/o SPF**
Delmhorst	0	24	0	20	0	24
Protimeter	0	15-18	0	20	0	22
tramex	0	18	0	20+	0	20+
Ryobi	0	51	16	24	0	32-34
Termatrac T3i	9-15	30+	0-16	30+	14	30+
Laser temp ºC	27/26.5	27.3	26.9	26.8	27	26.3
Termatrac T3i motion detector	Termatrac found movement through foam and on tube. Live termites seen during destructive sampling		Termatrac found movement through foam. Live termites seen during destructive sampling		Termatrac found movement through foam. Live termites seen during destructive sampling	

D. Readings taken August 15, 2019 one month after application and *after* SPF removal.

	Location Zero (on block)		Location 5 (on wood beam)		Location 5 (on wood sill)	
Meter type	**under SPF**	**w/o SPF**	**under SPF**	**w/o SPF**	**under SPF**	**w/o SPF**
Delmhorst	NA	30+	28	20	30+	24
Protimeter	NA	14-17	32	20	30	24
tramex	NA	17.5	20+	20+	20+	20+
Ryobi	NA	33	100	26	100	34
Termatrac T3i	NA	29-30+	18	28-30+	23	30+
Laser temp ºC	NA	26.7	27.4	28.2	26.8	27.4

	Location 20 (on block)		Location 15 (on wood beam)		Location 15 (on wood sill)	
Meter type	**under SPF**	**w/o SPF**	**under SPF**	**w/o SPF**	**under SPF**	**w/o SPF**
Delmhorst	NA	24	28	20	30+	24
Protimeter	NA	15-18	28	22	50	24
tramex	NA	18	20+	20+	20+	20+
Ryobi	NA	51	100	24	100	32-34
Termatrac T3i	NA	30+	27	30+	25	30+
Laser temp ºC	NA	27.3	26.3	26.8	26.2	26.3

Table 2. Summary of locations (indicated by placement of 'red arrows') associated with observation of termite activity by inspection date and inspector/method.

Device/method used to identify termite activity by Inspector	Number of red arrows (signs of termite activity)		
	July 16 Before SPF application	July 17 No SPF	On SPF
Visual; Inspector #1	14	14	0
Visual/ IR Camera; Inspector #2	3	0	0
Termatrac T3i; Inspector #3	6	11	6
Visual; Inspector #4	5	5	0
Visual; Inspector #5	10	9	0

Appendix 1.

Photograph 1. Images taken during the September 6th, 2019 renovations showing the termite activity, by the red arrows, along the block foundation wall behind the joist header in the southeast corner of crawlspace at locations 0 and 5. The infestation likely accessed the structural lumber from the expansion joint between the slab and block wall (green arrow).

Photograph 2. Pictures of the floor joists between Locations 10 & 15 exposed during renovations conducted 6 September 2019. Pictures of each joist are arranged, left-to-right, by proximity to the joist header (on the left in this image) along the south wall of the crawlspace.