Appendix A: MTU Final Outdoor Exposure Test Results (2/2021)

1. E18 – Ground Proximity
2. E16 – Above Ground Lap Joint
3. E9- Fenestration L-Joint

Appendix A: MTU Final Outdoor Exposure Test Results (2/2021)

1. E18 – Ground Proximity

Michigan Technological University
College of Forest Resources and Environmental Science

Matt Aro
Natural Resources Research Institute
5013 Miller Trunk Highway
Duluth, MN 55811

April 12, 2021

Dear Matt,

This letter serves as an extra report for Project E48057B, **Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E18).** The decay blocks were evaluated on February 11, 2021 at the Michigan Tech Wood Protection Group (WPG) Kipuka Field Test Site near Hilo, HI. Kipuka site characteristics, climate data during the exposure period, and the test exposure history are included in Appendix A. Ground proximity decay test data is summarized in Figures 1 and 2 and tabulated data is attached as Appendix B.

Decay Blocks (48 Months, Evaluation 4 of 4 for Current Agreement)

The Natural Resources Research Institute at the University of Minnesota at Duluth (NRRI) prepared ground proximity decay blocks from four deciduous and three conifer species. The hardwoods are yellow poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), white ash (*Fraxinus americana*), and aspen (*Populus tremuloides*). Each of these species was modified by thermal treatment at 170°C or 180°C. Balsam fir (*Abies balsamea*) was also subjected to the thermal treatments. Ponderosa (*Pinus ponderosa*) and southern (*Pinus* spp.) were prepared, without thermal treatment as benchmarks. The decay blocks were shipped to the WPG in Houghton, MI for additional processing.

Synergies between DOT and thermal treatment were tested using yellow poplar and red maple. Blocks were pressure-treated with the recommended above ground retention for southern pine (4.5 kg/m^3) and sorted into two groups. One group was used as the DOT benchmark. The other group was sent to NRRI for thermal modification at 170°C and returned to WPG for the test. Southern pine was pressure-treated to a target retention of 1.0 kg/m^3, 2.0 kg/m^3, or 4.0 kg/m^3 with ACQ-C.[1] Ponderosa pine was dip-treated for three minutes using Woodtreat Millwork®[2] at a 4 to 1 dilution of the concentrate with water. After these treatments were completed, all decay blocks were uniquely labelled using stainless steel ID tags and fasteners.

[1] Current Version: AWPA Standard P28-14, *Standard for Alkaline Copper Quat Type C (ACQ-C)*, American Wood Protection Association (2019) Birmingham, AL USA.

[2] Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA). The active biocides are 3-Iodoprop-2-yn-1-yl butylcarbamate (IPBC), tebuconazole, and propiconazole.

The field-ready blocks were shipped to the test site near Hilo, HI, and installed in an AWPA E18[3] decay test during February 2017. Sue French (NRRI) was present and assisted with the installation. They were visually evaluated for decay and insect attack at the times shown in Table A2 (Appendix A). Statistical analysis on the data was performed using JMP Pro 15.[4] At 48 months of field exposure:

A. Untreated Controls: Decay was universally severe among the untreated control ground proximity decay blocks of the wood species that were thermally modified in this study. Yellow poplar and aspen were the only species with remaining replicates (Figure 1, Tables B1 and B2). No untreated control block had a visible decay rating above 4. All other untreated control blocks had failed due to decay by 48 months of field exposure.

B. Benchmark Treatments: Yellow poplar and red maple blocks treated with DOT were severely decayed and had experienced multiple failures due to decay (Figure 2, Tables B1 and B2). Ponderosa pine blocks treated with WoodTreat Millwork® were also severely decayed. Southern pine blocks treated with ACQ-C had variable visible decay that spanned minor to severe with an apparent dose response.

C. Thermal Modification (180°C): Thermal modification of blocks at 180°C initially appeared to improve the decay resistance of the hardwoods in this test when compared to their untreated controls (Figure 1, Tables B1 and B2). Only white ash blocks, among these hardwoods, continued to show improved decay resistance compared to its untreated controls during the 48-month evaluation. The yellow poplar, red maple, and aspen blocks each had mean visible decay ratings between 4 and 6. White ash had a mean visible decay rating between 7 and 8. Decay ratings of 7 or less are generally considered as non-serviceable for the intended use of the wood. Thermal modification of blocks at 180°C appeared to improve the decay resistance of the balsam fir blocks compared to their untreated controls.

   Although not directly comparable to each other, thermal modification (180°C) these balsam fir blocks may impart improved decay resistance compared to WoodTreat Millwork and may impart equivalent decay resistance to ACQ-C. Direct comparisons using ponderosa pine and southern pine would be useful.

D. Thermal Modification (170°C): Thermal modification at 170°C did not significantly improve the decay resistance of any of the wood species in this test. One block each of yellow poplar and aspen remained after this evaluation. They both had visible decay ratings of 4. All decay block types modified by thermal treatment at 170°C had lower decay resistance blocks thermally modified at 180°C, southern pine blocks treated at all retentions of ACQ-C, or ponderosa pine treated with Woodtreat Millwork (Table B1).

[3] Current Version: AWPA Standard E18-18, *Standard Field Test for Evaluation of Wood Preservatives to Be Used Above Ground (UC3B); Ground Proximity Decay Test,* American Wood Protection Association (2020) Birmingham, AL USA.
[4] JMP Pro 15 (2019) SAS Institute Inc., Cary NC, USA

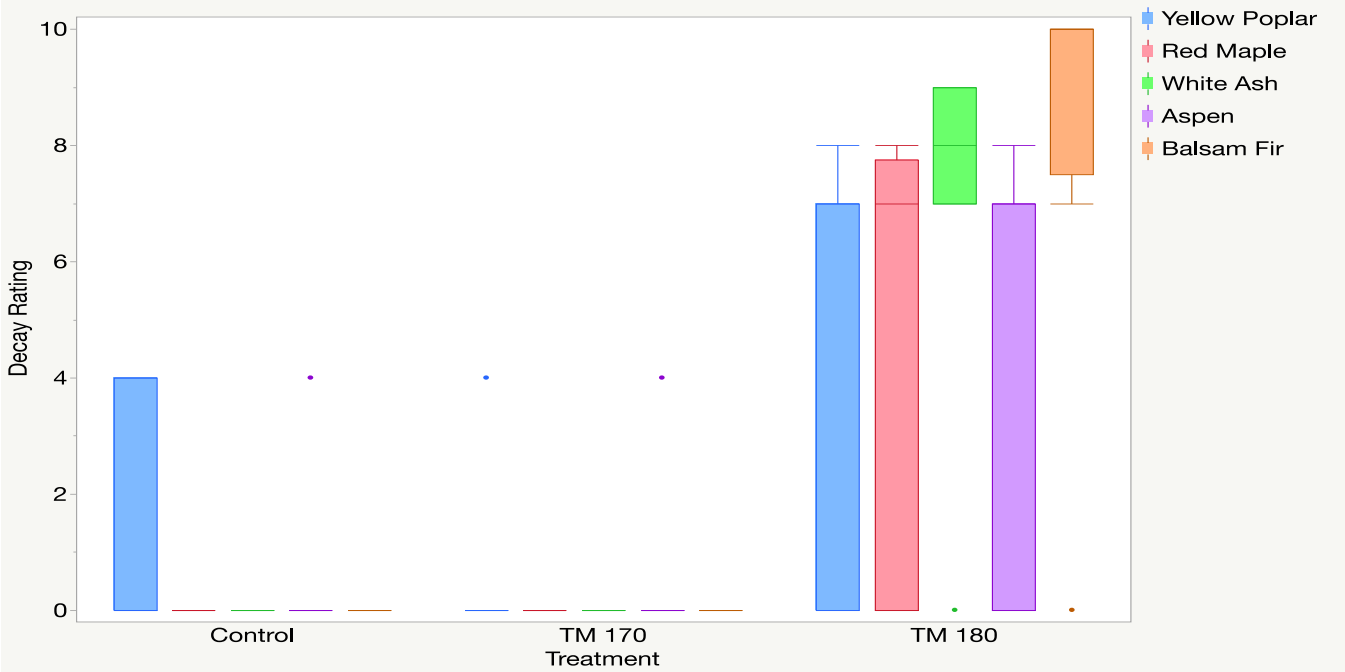

Figure 1. Box plot showing the effect of thermal modification at 170°C (TM 170) or 180°C (TM 180) on the decay resistance of wood after it has been exposed in an AWPA E18 decay test at the WPG Kipuka Field Test Site near Hilo, HI, for a period of 48 months. The dots indicate outliers. When the minimum or maximum value are not part of the box or an outlier, they are indicated by the whiskers. Lines dividing the inside of the boxes are medians. In this instance some medians are equal to the first or third quantiles that define the lower and upper box borders.

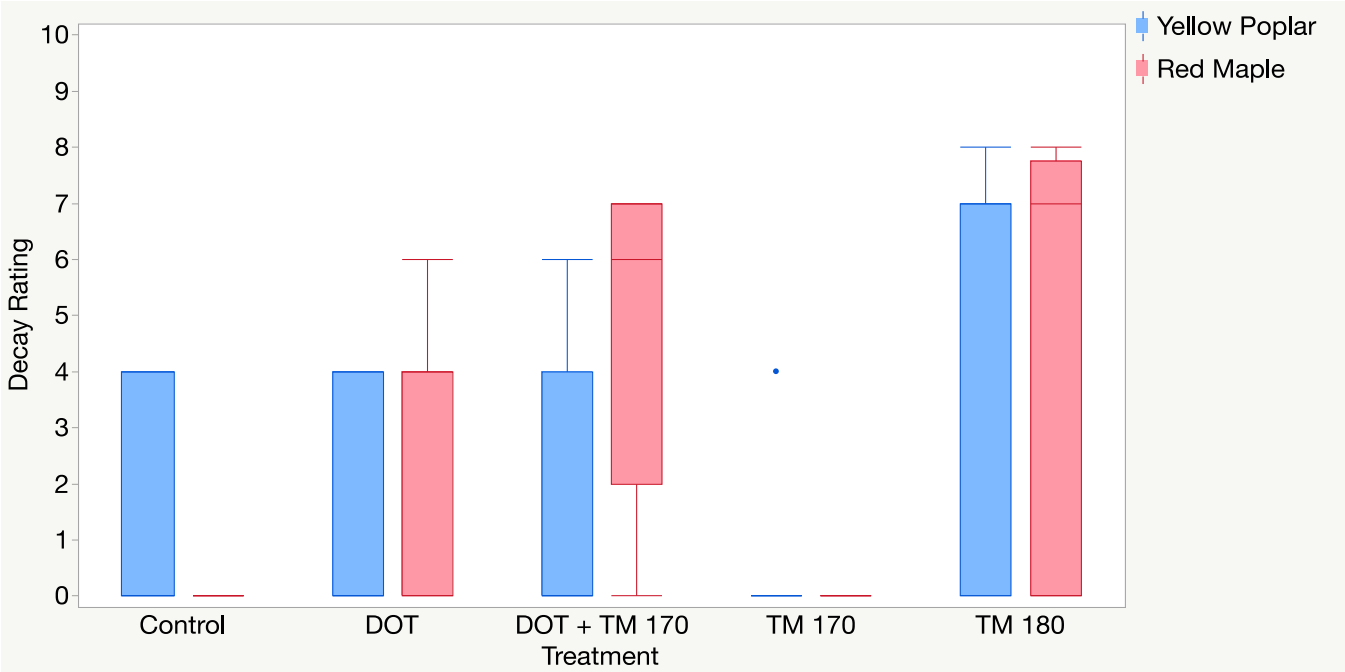

Figure 2. Box plot showing the effect of DOT and/or thermal modification at 170°C (TM 170 + DOT) on the decay resistance of yellow poplar and red maple exposed in an AWPA E18 decay test at the WPG Kipuka Field Test Site near Hilo, HI, for a period of 48 months. The dots indicate outliers. When the minimum or maximum value are not part of the box or an outlier, they are indicated by the whiskers. Lines dividing the inside of the boxes are medians. In this instance the medians are equal to the first or third quantiles that define the lower and upper box borders.

E. Thermal Modification (170°C) + DOT: There was no apparent synergy between the DOT and thermal (170°C) treatments. Thermal treatment at 180°C does not appear to be more effective than the DOT treatments for improving decay resistance during this ground proximity decay test exposure.

F. Insect Attack: There was variable, non-termite, insect attack among the decay blocks.

This was the last agreed upon evaluation for project E48057B. Continued evaluations or follow-up tests should be considered. The data in this and other related field tests[5] at the WPG Kipuka Field Test Site shows potential for long-term durability of some species of thermally modified wood treated at 180°C in exterior above ground applications corresponding to AWPA UC3.[6] This would include end uses such as coated millwork and siding (UC3A) or decking and fence pickets (UC3B). However, more testing is needed to confirm these applications as appropriate uses for the thermally modified wood. It should be noted that the AWPA E18 test is particularly harsh, and the results might be expected to reflect the more severe exposure conditions than any of the ongoing related tests.

We welcome your questions or comments. I may be reached by telephone at (906) 487-3316 or e-mail at gmlarkin@mtu.edu. Dr. Xinfeng Xie, WPG Group Leader, may be reached at (906) 487-2294 or xinfengx@mtu.edu.

Yours truly,

Glenn M. Larkin

Glenn M. Larkin
Sr. Research Scientist
Wood Protection Group

Cc: File: E48057B

[5] Project E48057A, *Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E16)*; and Project E48057C, *Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E9).*

[6] AWPA Standard U1-20, *Use Category System: User Specifications for Treated Wood*, American Wood Protection Association (2020) Birmingham, AL USA.

Appendix A: Test Site Information and Project Exposure History

Table A1. Summary of WPG Kipuka Field Test Site Characteristics

Test Site	Location	Climate Station	Station Number	Mean Annual Precipitation		Mean Annual Temperature		Scheffer Index	Soil Type		Known Fungi*		Known Insects*	
Kipuka	Kea'au, HI (USA)	Hilo Int'l Airport	511492	3220 mm	127"	23°C	74°F	330	Silty Clay Loam	Hilo Series	*Alternaria* spp.	Mold / Soft Rot	*Xylocopa* spp.	Carpenter Bee
											Antrodia vaillantii	Brown Rot		
											Antrodia xantha	Brown Rot		
											Cladosporium spp.	Mold / Soft Rot		
											Coniophora spp.	Brown Rot		
											Curvularia spp.	Mold / Soft Rot		
											Dacrymyces spp.	Brown Rot		
											Epicoccum spp.	Mold / Soft Rot		
											Fusarium spp.	Mold / Soft Rot		
											Hyphoderma spp.	White Rot		
											Neolentinus lepideus	Brown Rot		
											Paecilomyces spp.	Mold / Soft Rot		
											Penicillium spp.	Mold / Soft Rot		
											Perenniporia tephropora	White Rot		
											Phanaerochaete spp.	White Rot		
											Pleurotus ostreatus	White Rot		
											Pycnoporus cinnabarinus	White Rot		
											Sistotrema spp.	Brown Rot		
											Trichoderma spp.	Mold / Soft Rot		

*Isolated or observed by WPG

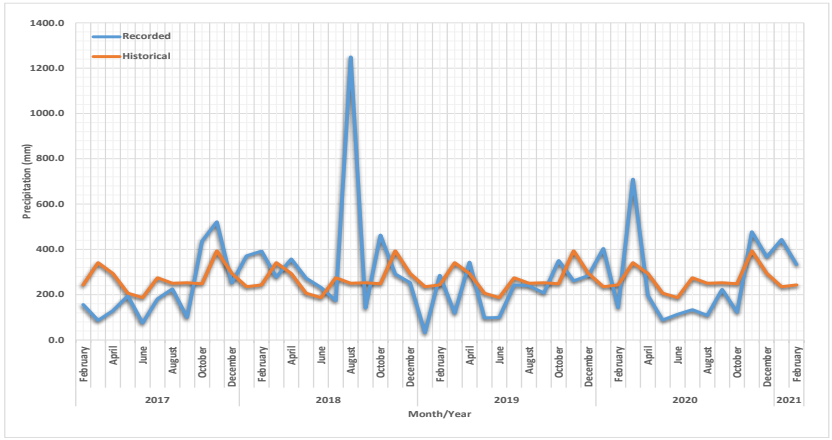

Figure A1. Measured (blue) and mean historical (red) monthly precipitation at the WPG Kipuka Field Test Site (red) during the field exposure.

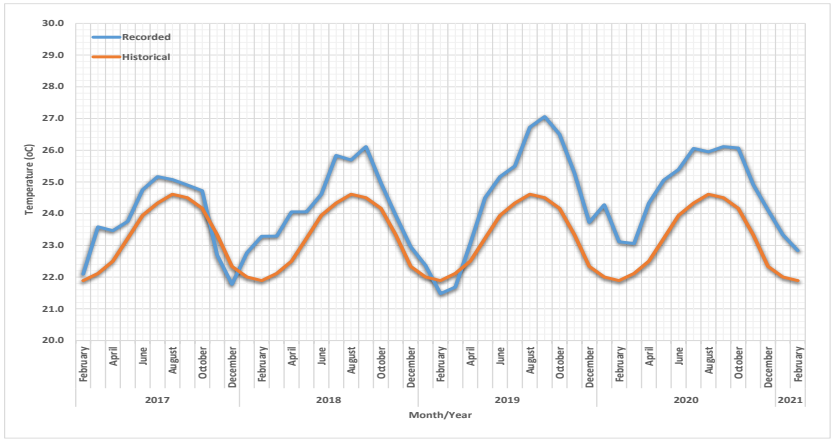

Figure A2. Measured mean (blue) and mean historical (red) monthly temperature at the WPG Kipuka Field Test Site (red) during the field exposure.

Table A2. Exposure and Inspection History of Specimens Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI

Test Site	Project#	Project Name	Test Method	WPG SOP	Specimen Type	Installation/Renewal Date	Inspection Date
Kipuka	E48057B	Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (AWPA E18)	AWPA E18	565	Decay Blocks	February 2017	
	48						Feb' 2021
	36						Feb' 2020
	24						Feb' 2019
	12						Feb' 2018

Appendix B: Ground Proximity Decay Test Data

Table B1. Mean Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B)

Blocks	Type	1	2	3	4	5	6	7	8	9	10	11	12	13
	Species	Yellow Poplar					Red Maple					White Ash		
	Thermal Modification (°C)	180	170	170	N/A	N/A	180	170	170	N/A	N/A	180	170	N/A
	Preservative System	N/A		DOT[a]	DOT	N/A			DOT	DOT	N/A			
	Target Retention (kg/m^3)			4.5	4.5				4.5	4.5				
February	Exposure (Months)	Mean Decay Rating												
2017	0	Installed												
2018	12	10	8.1	9.0	8.6	8.5	9.9	8.9	9.7	9.6	7.2	10	9.0	8.7
2019	24	8.0	5.3	7.1	6.9	6.9	8.1	3.8	8.2	7.8	5.0	10	2.5	4.5
2020	36	6.3	1.0	5.3	5.1	5.2	7.0	0.0	7.4	5.9	1.3	10	0.0	0.8
2021	48	4.7	0.5	2.0	1.5	1.3	4.6	0.0	4.8	2.9	0.0	7.7	0.0	0.0
February	Exposure (Months)	Mean Insect Rating												
2017	0	Installed												
2018	12	10	10	10	9.6	9.6	10	10	10	10	10	10	9.9	9.9
2019	24	10	8.9	8.6	8.5	8.6	10	9.2	9.0	9.1	9.8	10	8.9	9.3
2020	36	9.9	8.2	8.3	7.6	7.9	10	8.0	9.0	8.7	8.3	10	8.0	7.8
2021	48	9.1	6.0	5.9	6.6	6.9	9.2	DF	8.4	7.1	6.5	10	DF	6.0

Table B1. Mean Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Blocks	Type	14	15	16	17	18	19	20	21	22	23	24
	Species	Balsam Fir			Ponderosa Pine	Southern Pine				Aspen		
	Thermal Modification (°C)	180	170	N/A						180	170	N/A
	Preservative System	N/A			WoodTreat Millwork[a]	ACQ-C[a,b]			N/A			
	Target Retention (kg/m^3)				0.21	1.0	2.0	4.0				
February	Exposure (Months)	Mean Decay Rating										
2017	0	Installed										
2018	12	9.6	10	7.5	9.7	9.5	10	10	9.4	9.9	9.5	8.1
2019	24	8.6	4.7	2.1	8.3	8.0	9.1	9.9	8.4	8.0	5.6	4.8
2020	36	8.7	2.5	0.4	7.3	8.2	7.3	10	6.6	8.1	1.1	4.2
2021	48	8.1	0.0	0.0	5.8	5.8	6.4	9.6	1.9	4.4	0.6	0.4
February	Exposure (Months)	Mean Insect Rating										
2017	0	Installed										
2018	12	10	10	9.9	10	10	10	10	10	10	9.9	9.7
2019	24	10	9.6	8.5	9.6	10	10	10	9.6	9.9	9.4	8.8
2020	36	10	9.3	8.3	9.6	10	9.8	9.6	9.9	10	8.7	8.7
2021	48	9.6	9.0	6.0	8.9	9.2	9.6	10	8.3	9.4	7.5	7.0

[a] DOT = disodium octaborate tetrahydrate, ACQ-C = Ammoniacal Copper Quat Type C, Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA)

[b] Data corrected 2020-03-12 to reflect proper tag assignments for block types 18 and 20. They were originally reversed.

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B)

Type	Species	Yellow Poplar		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m^3)				N/A
1	"P" Series	7041	7042	7043	7044	7045	7046	7047	7048	7049	7050	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI[a]	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	8	9	0	10	7	HL[e]	9	10	9	8.0	3.2	1.1	5.9	10
2020	36	9	8	7	0	8	0	HL	8	9	8	6.3	3.6	1.2	4.0	8.7
2021	48	8	0	7	0	7	0	HL	7	6	7	4.7	3.5	1.2	2.4	7.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	HL	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	DF	10	10	HL	10	10	9	9.9	0.4	0.1	9.6	10
2021	48	10	9	9	DF	9	DF	HL	9	9	9	9.1	0.4	0.1	8.9	9.4

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m^3)				N/A
2	"P" Series	7051	7052	7053	7054	7055	7056	7057	7058	7059	7060	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	9	7	0	10	8	8	10	9	8.1	3.0	1.0	6.2	10
2019	24	6	HL	0	0	0	8	7	7	9	HL	4.6	3.9	1.4	1.9	7.3
2020	36	0	HL	0	0	0	8	0	0	0	HL	1.0	2.8	1.0	0.0	3.0
2021	48	0	HL	0	0	0	4	0	0	0	HL	0.5	1.4	0.5	0.0	1.5
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	8	HL	10	7	DF	8	9	10	10	HL	8.9	1.2	0.5	8.0	9.8
2020	36	8	HL	DF	DF	DF	9	9	8	7	HL	8.2	0.8	0.4	7.5	8.9
2021	48	DF	HL	DF	DF	DF	6	DF	DF	DF	HL	6.0	0.0	0.0	6.0	6.0

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			170	Preservative System			DOT[b]	Target Retention (kg/m^3)				4.5
3	"P" Series	7061	7062	7063	7064	7065	7066	7067	7068	7069	7070	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	8	8	9	10	9	9	10	9	9	9	9.0	0.7	0.2	8.6	9.4
2019	24	6	7	7	HL	8	7	8	7	HL	HL	7.1	0.7	0.3	6.6	7.7
2020	36	6	6	6	HL	7	6	6	0	HL	HL	5.3	2.4	0.9	3.5	7.0
2021	48	0	0	4	HL	4	6	0	0	HL	HL	2.0	2.6	1.0	0.1	3.9
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	8	9	8	HL	9	8	8	10	HL	HL	8.6	0.8	0.3	8.0	9.2
2020	36	8	8	9	HL	8	8	9	8	HL	HL	8.3	0.5	0.2	7.9	8.6
2021	48	6	6	7	HL	7	7	8	0	HL	HL	5.9	2.7	1.0	3.9	7.8

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			N/A	Preservative System		DOT		Target Retention (kg/m³)				4.5
4	"P" Series	7071	7072	7073	7074	7075	7076	7077	7078	7079	7080	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	8	9	8	8	9	8	9	8	10	8.6	0.7	0.2	8.2	9.0
2019	24	7	HL	7	7	7	7	HL	7	6	7	6.9	0.4	0.1	6.6	7.1
2020	36	6	HL	6	4	7	0	HL	6	6	6	5.1	2.2	0.8	3.6	6.7
2021	48	0	HL	4	0	0	0	HL	4	0	4	1.5	2.1	0.7	0.1	2.9
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	9	10	9	10	9	10	9.6	0.5	0.2	9.3	9.9
2019	24	10	HL	8	8	9	8	HL	8	9	8	8.5	0.8	0.3	8.0	9.0
2020	36	9	HL	8	7	8	7	HL	7	7	8	7.6	0.7	0.3	7.1	8.1
2021	48	6	HL	7	6	7	DF	HL	6	7	7	6.6	0.5	0.2	6.2	7.0

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)				N/A
5	"P" Series	7081	7082	7083	7084	7085	7086	7087	7088	7089	7090	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	8	8	9.5	9	7	8	7	9	9	8.5	1.0	0.3	7.8	9.1
2019	24	8	6	7	HL	7	7	7	6	7	7	6.9	0.6	0.2	6.5	7.3
2020	36	6	6	7	HL	4	0	6	6	6	6	5.2	2.1	0.7	3.8	6.6
2021	48	4	0	0	HL	0	0	4	4	0	0	1.3	2.0	0.7	0.0	2.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	10	8	10	9	10	10	9.6	0.7	0.2	9.2	10
2019	24	9	8	10	HL	8	9	9	8	8	8	8.6	0.7	0.2	8.1	9.0
2020	36	7	8	9	HL	8	8	7	8	7	9	7.9	0.8	0.3	7.4	8.4
2021	48	7	8	7	HL	7	DF	7	6	6	7	6.9	0.6	0.2	6.4	7.3

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			180	Preservative System		N/A		Target Retention (kg/m³)				N/A
6	"P" Series	7091	7092	7093	7094	7095	7096	7097	7098	7099	7100	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2019	24	8	9	10	10	HL	10	10	0	HL	8	8.1	3.4	1.2	5.8	10
2020	36	9	8	10	10	HL	10	9	0	HL	0	7.0	4.4	1.5	4.0	10
2021	48	7	8	7	0	HL	7	8	0	HL	0	4.6	3.9	1.4	2.0	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	HL	10	10	10	HL	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	HL	10	10	DF	HL	10	10	0.0	0.0	10	10
2021	48	9	9	10	9	HL	9	9	DF	HL	DF	9.2	0.4	0.2	8.8	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m³)				N/A
7	"P" Series	7101	7102	7103	7104	7105	7106	7107	7108	7109	7110	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	8	8	9	9	7	8	8.9	1.1	0.3	8.2	9.6
2019	24	8	HL	HL	HL	0	0	8	HL	0	7	3.8	4.2	1.7	0.5	7.2
2020	36	0	HL	HL	HL	0	0	0	HL	0	0	0.0	0.0	0.0	0.0	0.0
2021	48	0	HL	HL	HL	0	0	0	HL	0	0	0.0	0.0	0.0	0.0	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	HL	HL	HL	9	8	10	HL	9	9	9.2	0.8	0.3	8.6	9.8
2020	36	7	HL	HL	HL	DF	DF	8	HL	DF	9	8.0	1.0	0.6	6.9	9.1
2021	48	DF	HL	HL	HL	DF	DF	DF	HL	DF	DF	DF	DF	DF	DF	DF

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			170	Preservative System			DOT	Target Retention (kg/m³)				4.5
8	"P" Series	7111	7112	7113	7114	7115	7116	7117	7118	7119	7120	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	9	10	10	10	9	10	9.7	0.5	0.2	9.4	10
2019	24	7	HL	9	HL	HL	9	HL	8	HL	8	8.2	0.8	0.4	7.5	8.9
2020	36	7	HL	8	HL	HL	8	HL	7	HL	7	7.4	0.5	0.2	6.9	7.9
2021	48	0	HL	7	HL	HL	7	HL	6	HL	4	4.8	2.9	1.3	2.2	7.4
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	8	HL	10	HL	HL	9	HL	9	HL	9	9.0	0.7	0.3	8.4	9.6
2020	36	8	HL	9	HL	HL	9	HL	10	HL	9	9.0	0.7	0.3	8.4	9.6
2021	48	8	HL	9	HL	HL	9	HL	8	HL	8	8.4	0.5	0.2	7.9	8.9

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			N/A	Preservative System			DOT	Target Retention (kg/m³)				4.5
9	"P" Series	7121	7122	7123	7124	7125	7126	7127	7128	7129	7130	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	9	10	9	10	10	9	9	10	9.6	0.5	0.2	9.3	10
2019	24	HL	7	8	8	8	8	7	8	8	8	7.8	0.4	0.1	7.5	8.1
2020	36	HL	7	7	7	7	8	6	4	7	0	5.9	2.5	0.8	4.3	7.5
2021	48	HL	4	4	4	4	6	0	0	4	0	2.9	2.3	0.8	1.4	4.4
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	HL	8	10	9	9	10	9	9	9	9	9.1	0.6	0.2	8.7	9.5
2020	36	HL	9	10	8	9	9	8	8	9	8	8.7	0.7	0.2	8.2	9.1
2021	48	HL	7	7	7	8	8	7	6	7	DF	7.1	0.6	0.2	6.7	7.6

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m³)				N/A
10	"P" Series	7131	7132	7133	7134	7135	7136	7137	7138	7139	7140	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	8	6	8	7	7	7	8	7	7	7	7.2	0.6	0.2	6.8	7.6
2019	24	8	HL	0	4	7	6	7	8	0	HL	5.0	3.3	1.2	2.7	7.3
2020	36	6	HL	0	0	4	0	0	0	0	HL	1.3	2.4	0.8	0.0	2.9
2021	48	0	HL	0	0	0	0	0	0	0	HL	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	HL	10	8	10	10	10	10	10	HL	9.8	0.7	0.3	9.3	10
2020	36	9	HL	DF	8	8	9	8	8	DF	HL	8.3	0.5	0.2	7.9	8.7
2021	48	6	HL	DF	DF	7	DF	DF	DF	DF	HL	6.5	0.7	0.5	5.5	7.5

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m³)				N/A
11	"P" Series	7141	7142	7143	7144	7145	7146	7147	7148	7149	7150	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	0	7	9	8	9	7	9	10	10	8	7.7	2.9	0.9	5.9	9.5
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	9	10	10	10	10	9	10	10	10	10	9.8	0.4	0.1	9.5	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m³)				N/A
12	"P" Series	7151	7152	7153	7154	7155	7156	7157	7158	7159	7160	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	8	10	10	7	9	7	10	9	10	10	9.0	1.2	0.4	8.2	9.8
2019	24	0	0	7	0	8	0	0	0	0	10	2.5	4.1	1.3	0.0	5.0
2020	36	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
2021	48	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	9	10	9.9	0.3	0.1	9.7	10
2019	24	10	8	10	8	8	8	8	9	10	10	8.9	1.0	0.3	8.3	9.5
2020	36	DF	DF	7	DF	7	DF	DF	DF	DF	10	8.0	1.7	1.0	6.0	10
2021	48	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m³)				N/A
13	"P" Series	7161	7162	7163	7164	7165	7166	7167	7168	7169	7170	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	8	10	8	9	9	9	7	9	9	8.7	0.8	0.3	8.2	9.2
2019	24	HL	HL	8	7	0	0	8	7	6	0	4.5	3.8	1.3	1.9	7.1
2020	36	HL	HL	0	0	0	0	6	0	0	0	0.8	2.1	0.8	0.0	2.2
2021	48	HL	HL	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	9	10	10	10	10	9.9	0.3	0.1	9.7	10
2019	24	HL	HL	9	10	10	10	8	8	9	10	9.3	0.9	0.3	8.6	9.9
2020	36	HL	HL	9	6	DF	DF	8	8	8	DF	7.8	1.1	0.5	6.8	8.8
2021	48	HL	HL	DF	DF	DF	DF	6	DF	DF	DF	6.0	DF	DF	DF	DF

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m³)				N/A
14	"P" Series	7171	7172	7173	7174	7175	7176	7177	7178	7179	7180	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	9	8	9	10	10	10	9.6	0.7	0.2	9.2	10
2019	24	9	10	10	10	9	0	10	9	HL	10	8.6	3.2	1.1	6.4	10
2020	36	8	10	10	10	10	0	10	10	HL	10	8.7	3.3	1.1	6.5	10
2021	48	7	10	10	10	8	0	10	8	HL	10	8.1	3.3	1.1	6.0	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	HL	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	DF	10	10	HL	10	10	0.0	0.0	10	10
2021	48	9	10	10	10	9	DF	10	9	HL	10	9.6	0.5	0.2	9.3	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m³)				N/A
15	"P" Series	7181	7182	7183	7184	7185	7186	7187	7188	7189	7190	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	HL	HL	9	10	4	4	6	HL	0	0	4.7	3.9	1.5	1.8	7.6
2020	36	HL	HL	M	7	0	0	8	HL	0	0	2.5	3.9	1.6	0.0	5.6
2021	48	HL	HL	M	0	0	0	0	HL	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	HL	HL	10	10	10	9	10	HL	9	9	9.6	0.5	0.2	9.2	10
2020	36	HL	HL	M	10	8	10	9	HL	DF	DF	9.3	1.0	0.5	8.3	10
2021	48	HL	HL	M	8	DF	DF	10	HL	DF	DF	9.0	1.4	1.0	7.0	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m³)				N/A
16	"P" Series	7191	7192	7193	7194	7195	7196	7197	7198	7199	7200	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	8	8	7	6	10	9	8	9	4	6	7.5	1.8	0.6	6.4	8.6
2019	24	0	6	0	4	7	0	0	4	0	0	2.1	2.8	0.9	0.3	3.9
2020	36	0	0	0	0	4	0	0	0	0	0	0.4	1.3	0.4	0.0	1.2
2021	48	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	9	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2019	24	7	9	9	8	9	7	10	8	10	8	8.5	1.1	0.3	7.8	9.2
2020	36	DF	9	DF	7	9	DF	DF	8	DF	DF	8.3	1.0	0.5	7.3	9.2
2021	48	DF	DF	DF	DF	6	DF	DF	DF	DF	DF	6.0	DF	DF	DF	DF

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Ponderosa Pine		Thermal Modification (°C)			N/A	Preservative System		WoodTreat Millwork[b]		Target Retention (kg/m³)				0.21
17	"P" Series	7201	7202	7203	7204	7205	7206	7207	7208	7209	7210	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	9	9	10	10	10	9	10	10	9.7	0.5	0.2	9.4	10
2019	24	8	8	HL	8	8	8	8	HL	10	8	8.3	0.7	0.3	7.8	8.7
2020	36	7	6	HL	7	7	8	8	HL	8	7	7.3	0.7	0.3	6.8	7.7
2021	48	6	4	HL	6	6	6	6	HL	8	4	5.8	1.3	0.5	4.9	6.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	8	HL	9	10	10	10	HL	10	10	9.6	0.7	0.3	9.1	10
2020	36	9	9	HL	10	10	10	10	HL	10	9	9.6	0.5	0.2	9.3	10
2021	48	9	9	HL	9	9	9	9	HL	9	8	8.9	0.4	0.1	8.6	9.1

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type[d]	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C[b]		Target Retention (kg/m³)				1.0
18	"P" Series	7231	7232	7233	7234	7235	7236	7237	7238	7239	7240	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	8	10	8	9	10	10	0.8	0.3	9.0	10
2019	24	9	10	8	HL	0	8	9	8	10	10	8.0	3.1	1.0	6.0	10
2020	36	10	10	10	HL	0	8	10	7	10	9	8.2	3.3	1.1	6.1	10
2021	48	8	M	M	HL	0	6	8	6	M	7	5.8	3.0	1.2	3.4	8.2
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	HL	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	HL	10	10	10	M	10	10	10	0.0	0.0	10	10
2021	48	10	M	M	HL	M	9	9	9	M	9	9.2	0.4	0.2	8.8	9.6

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C		Target Retention (kg/m³)				2.0
19	"P" Series	7241	7242	7243	7244	7245	7246	7247	7248	7249	7250	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	HL	10	10	9	6	9	9	9	10	9.1	1.3	0.4	8.3	9.9
2020	36	9	HL	10	10	9	0	9	9	0	10	7.3	4.2	1.4	4.6	10
2021	48	9	HL	9	9	7	0	7	8	0	9	6.4	3.7	1.2	4.0	8.9
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	HL	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	HL	10	10	10	8	10	10	10	10	9.8	0.7	0.2	9.3	10
2021	48	10	HL	10	10	9	DF	10	9	DF	9	9.6	0.5	0.2	9.2	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type[d]	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C		Target Retention (kg/m³)				4.0
20	"P" Series	7211	7212	7213	7214	7215	7216	7217	7218	7219	7220	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	9	10	HL	10	10	10	HL	10	10	9.9	0.4	0.1	9.6	10
2020	36	10	10	10	HL	10	10	10	HL	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	HL	10	9	10	HL	8	10	9.6	0.7	0.3	9.1	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	HL	10	10	10	HL	10	10	10	0.0	0.0	10	10
2020	36	10	8	9	HL	10	10	10	HL	10	10	9.6	0.7	0.3	9.1	10
2021	48	10	10	10	HL	10	10	10	HL	10	10	10	0.0	0.0	10	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)				N/A
21	"P" Series	7221	7222	7223	7224	7225	7226	7227	7228	7229	7230	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	9	9	10	9	8	10	9.4	0.7	0.2	9.0	9.8
2019	24	10	8	8	HL	8	9	9	8	7	9	8.4	0.9	0.3	7.9	9.0
2020	36	6	7	8	HL	8	6	8	8	0	8	6.6	2.6	0.9	4.9	8.3
2021	48	0	0	0	HL	0	6	4	7	0	0	1.9	2.9	1.0	0.0	3.8
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	9	HL	8	9	10	10	10	10	9.6	0.7	0.2	9.1	10
2020	36	10	10	10	HL	9	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2021	48	8	8	8	HL	8	8	8	9	DF	9	8.3	0.5	0.2	7.9	8.6

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m³)				N/A
22	"P" Series	7231	7232	7233	7234	7235	7236	7237	7238	7239	7240	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	9	10	10	10	9.9	0.3	0.1	9.7	10
2019	24	8	HL	9	9	9	10	0	9	9	9	8.0	3.0	1.0	6.0	10
2020	36	8	HL	10	10	8	9	0	10	8	10	8.1	3.2	1.1	6.0	10
2021	48	7	HL	4	7	7	7	0	0	0	8	4.4	3.5	1.2	2.2	6.7
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	HL	10	10	10	10	9	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	10	HL	10	10	10	10	DF	10	10	10	10	0.0	0.0	10	10
2021	48	9	HL	10	9	9	9	DF	10	10	9	9.4	0.5	0.2	9.0	9.7

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m³)				N/A
23	"P" Series	7241	7242	7243	7244	7245	7246	7247	7248	7249	7250	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	10	10	9	10	10	10	9	9	9	9.5	0.5	0.2	9.2	9.8
2019	24	7	HL	8	6	4	7	HL	7	HL	0	5.6	2.8	1.0	3.5	7.6
2020	36	0	HL	0	0	0	4	HL	4	HL	0	1.1	2.0	0.7	0.0	2.6
2021	48	0	HL	0	0	0	4	HL	0	HL	0	0.6	1.5	0.6	0.0	1.7
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	9	10	9.9	0.3	0.1	9.7	10
2019	24	10	HL	10	10	10	9	HL	9	HL	8	9.4	0.8	0.3	8.8	10
2020	36	7	HL	9	8	8	10	HL	10	HL	DF	8.7	1.2	0.5	7.7	9.6
2021	48	DF	HL	DF	DF	DF	7	HL	8	HL	DF	7.5	0.7	0.5	6.5	8.5

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m³)				N/A
24	"P" Series	7251	7252	7253	7254	7255	7256	7257	7258	7259	7260	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	7	8	7	9	8	9	8	8	8	9	8.1	0.7	0.2	7.6	8.6
2019	24	0	8	0	7	7	7	HL	8	0	6	4.8	3.6	1.2	2.4	7.2
2020	36	0	6	0	7	7	6	HL	6	0	6	4.2	3.2	1.1	2.1	6.3
2021	48	0	0	0	0	4	0	HL	0	0	0	0.4	1.3	0.4	0.0	1.3
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	9	10	9	10	10	9	10	9.7	0.5	0.2	9.4	10
2019	24	8	9	7	10	10	10	HL	8	7	10	8.8	1.3	0.4	7.9	9.6
2020	36	DF	8	DF	10	10	9	HL	7	DF	8	8.7	1.2	0.5	7.7	9.6
2021	48	DF	7	DF	7	7	8	HL	6	DF	7	7.0	0.6	0.3	6.5	7.5

[a] Lower CI = Lower 95% Confidence Interval, Upper CI = Upper 95% Confidence Interval

[b] DOT = disodium octaborate tetrahydrate, ACQ-C = Ammoniacal Copper Quat Type C, Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA)

[c] HL = Lost as a result of Hurricane Lane (August 22 - 26, 2018)

[d] Data corrected 2020-03-12 to reflect proper tag assignments for block types 18 and 20. They were originally reversed.

Michigan Technological University
College of Forest Resources and Environmental Science

Matt Aro
Natural Resources Research Institute
5013 Miller Trunk Highway
Duluth, MN 55811

April 14, 2021

Dear Matt,

This letter serves as the final report for Project WPG180122B, **Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E18 – Add On).** The decay blocks were evaluated on February 11, 2021 at the Michigan Tech Wood Protection Group (WPG) Kipuka Field Test Site near Hilo, HI. Kipuka site characteristics, climate data during the exposure period, and the test exposure history are included in Appendix A. Test data is attached as Appendix B.

Decay Blocks (36 Months, Evaluation 3 of 3 for Current Contract)

The Natural Resources Research Institute at the University of Minnesota at Duluth (NRRI) prepared ground proximity decay blocks for eastern hemlock (*Tsuga canadensis*) then modified them by thermal treatment at 170°C or 180°C. Southern (*Pinus* spp.) was prepared, without thermal treatment as a control. The lap joints were shipped to the WPG in Houghton, MI, where each was uniquely labelled using stainless steel ID tags and fasteners.

The field-ready blocks were shipped to the test site near Hilo, HI, and installed in an AWPA E18[1] decay test during February 2018. They were visually evaluated for decay and insect attack as shown in Table A2 (Appendix A). At 36 months of field exposure:

A. Untreated Controls: There was variable, mostly severe, visible decay among the untreated eastern hemlock and southern pine decay blocks. There have been multiple previous failures due to decay among the eastern hemlock blocks.

B. Thermal Modification: Test results seem to indicate that thermal modification at 180°C may improve decay resistance of eastern hemlock compared to thermal modification at 170°C and the untreated controls. There was minor visible decay among the eastern hemlock blocks heat-treated at 180°C. There was variable visible decay among the blocks heat-treated at 170°C, including one failure due to decay during this evaluation.

C. There was variable, non-termite, insect attack among the decay blocks.

[1] Current Version: AWPA Standard E18-18, *Standard Field Test for Evaluation of Wood Preservatives to Be Used Above Ground (UC3B); Ground Proximity Decay Test,* American Wood Protection Association (2020) Birmingham, AL USA.

This was the last contracted evaluation for project WPG160122B. Continued evaluations may be warranted. More time is needed to established the long-term decay resistance of thermally modified eastern hemlock using the AWPA E18 test format.

We welcome your questions or comments. I may be reached by telephone at (906) 487-3316 or e-mail at gmlarkin@mtu.edu. Dr. Xinfeng Xie, WPG Group Leader, may be reached at (906) 487-2294 or xinfengx@mtu.edu.

Yours truly,

Glenn M. Larkin

Glenn M. Larkin
Sr. Research Scientist
Wood Protection Group

Cc: File: WPG180122B

Appendix A: Test Site Information and Project Exposure History

Table A1. Summary of WPG Kipuka Field Test Site Characteristics

Test Site	Location	Climate Station	Station Number	Mean Annual Precipitation		Mean Annual Temperature		Scheffer Index	Soil Type		Known Fungi*		Known Insects*	
Kipuka	Kea'au, HI (USA)	Hilo Int'l Airport	511492	3220 mm	127"	23°C	74°F	330	Silty Clay Loam	Hilo Series	*Alternaria* spp.	Mold / Soft Rot	*Xylocopa* spp.	Carpenter Bee
											Antrodia vaillantii	Brown Rot		
											Antrodia xantha	Brown Rot		
											Cladosporium spp.	Mold / Soft Rot		
											Coniophora spp.	Brown Rot		
											Curvularia spp.	Mold / Soft Rot		
											Dacrymyces spp.	Brown Rot		
											Epicoccum spp.	Mold / Soft Rot		
											Fusarium spp.	Mold / Soft Rot		
											Hyphoderma spp.	White Rot		
											Neolentinus lepideus	Brown Rot		
											Paecilomyces spp.	Mold / Soft Rot		
											Penicillium spp.	Mold / Soft Rot		
											Perenniporia tephropora	White Rot		
											Phanaerochaete spp.	White Rot		
											Pleurotus ostreatus	White Rot		
											Pycnoporus cinnabarinus	White Rot		
											Sistotrema spp.	Brown Rot		
											Trichoderma spp.	Mold / Soft Rot		

*Isolated or observed by WPG

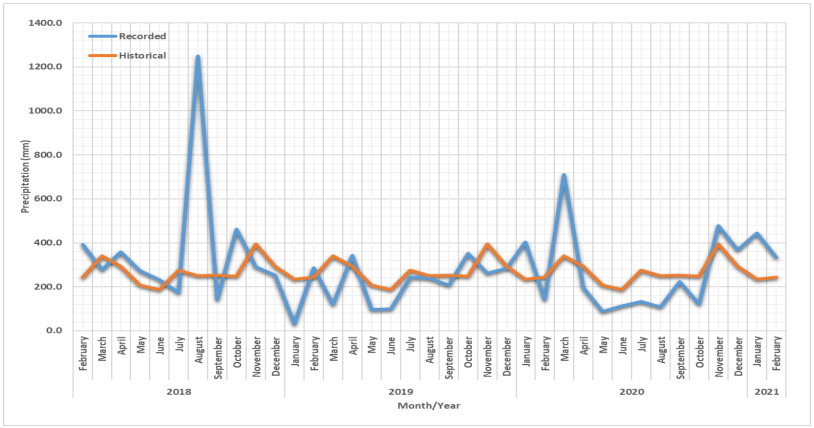

Figure A1. Measured (blue) and mean historical (red) monthly precipitation at the WPG Kipuka Field Test Site (red) during the field exposure.

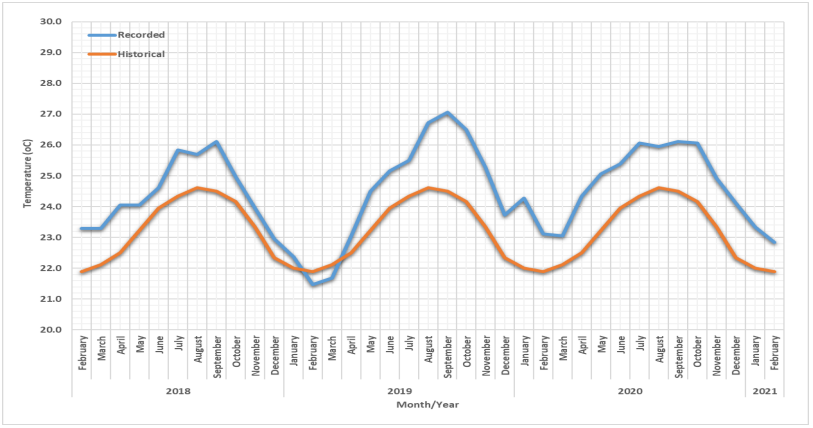

Figure A2. Measured mean (blue) and mean historical (red) monthly temperature at the WPG Kipuka Field Test Site (red) during the field exposure.

Table A2. Exposure and Inspection History of Specimens Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI

Test Site	Project#	Project Name	Test Method	WPG SOP	Specimen Type	Installation/Renewal Date	Inspection Date
Kipuka	WPG180122B	Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (AWPA E18)	AWPA E18	565	Decay Blocks	February 2018	
	36						Feb' 2021
	24						Feb' 2020
	12	Hurricane Lane (August 22 26, 2018)					Feb' 2019

Appendix B: Ground Proximity Decay Test Data

Table B1. Mean Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test (Project WPG180122B)[a]

Decay Blocks	Type	25	26	27	28
	Species	Eastern Hemlock			Southern Pine
	Thermal Modification (°C)	180	170	N/A	
February	Exposure (Months)	Mean Decay Rating			
2018	0	Installed			
2019	12	10	9.9	8.9	8.0
2020	24	10	9.8	7.1	8.2
2021	36	9.9	7.6	5.4	7.0
February	Exposure (Months)	Mean Insect Rating			
2018	0	Installed			
2019	12	10	10	9.8	10
2020	24	10	10	9.3	9.5
2021	36	10	9.0	8.8	8.4

[a] AWPA E18 Test Exposure at the WPG Kipuka Field Test Site near Hilo, HI

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122B)

Type	Species	Eastern Hemlock		Thermal Modification (°C)		180		Preservative System		N/A		Target Retention (kg/m^3)			N/A	
25	"P" Series	8541	8542	8543	8544	8545	8546	8547	8548	8549	8550	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI[a]	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	36	10	10	10	9	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122B) - *Continued*

Type	Species	Eastern Hemlock		Thermal Modification (°C)		170		Preservative System		N/A		Target Retention (kg/m^3)			N/A	
26	"P" Series	8551	8552	8553	8554	8555	8556	8557	8558	8559	8560	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	9	10	10	10	10	10	10	10	HL[b]	9.9	0.3	0.1	9.7	10
2020	24	10	9	10	10	10	10	9	10	10	HL	9.8	0.4	0.1	9.5	10
2021	36	9	7	9	10	0	7	9	9	8	HL	7.6	3.0	1.0	5.6	9.5
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	9	10	10	10	10	10	10	10	HL	9.9	0.3	0.1	9.7	10
2020	24	10	10	10	10	10	10	10	10	10	HL	10	0.0	0.0	10	10
2021	36	9	8	9	10	10	8	9	9	9	HL	9.0	0.7	0.2	8.5	9.5

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122B) - *Continued*

Type	Species	Eastern Hemlock		Thermal Modification (°C)		N/A		Preservative System		N/A		Target Retention (kg/m^3)			N/A	
27	"P" Series	8561	8562	8563	8564	8565	8566	8567	8568	8569	8570	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	8	10	7	10	10	9	10	10	7	8	8.9	1.3	0.4	8.1	9.7
2020	24	7	10	7	9	10	9	10	9	0	0	7.1	3.9	1.2	4.7	9.5
2021	36	4	7	6	7	7	7	8	8	0	0	5.4	3.1	1.0	3.5	7.3
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	10	10	10	8	10	9.8	0.6	0.2	9.4	10
2020	24	9	10	9	10	10	9	10	10	7	9	9.3	0.9	0.3	8.7	9.9
2021	36	9	9	8	9	8	8	9	10	DF	DF	8.8	0.7	0.3	8.3	9.2

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122B) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)		N/A		Preservative System		N/A		Target Retention (kg/m^3)		N/A		
28	"P" Series	8591	8592	8593	8594	8595	8596	8597	8598	8599	8600	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										**10**	**0.0**	**0.0**	**10**	**10**
2019	12	7	8	8	9	8	8	8	8	8	8	**8.0**	**0.5**	**0.1**	**7.7**	**8.3**
2020	24	8	10	8	7	8	8	8	8	8	9	**8.2**	**0.8**	**0.2**	**7.7**	**8.7**
2021	36	7	7	7	6	7	7	8	7	7	7	**7.0**	**0.5**	**0.1**	**6.7**	**7.3**
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										**10**	**0.0**	**0.0**	**10**	**10**
2019	12	10	10	10	10	10	10	10	10	10	10	**10**	**0.0**	**0.0**	**10**	**10**
2020	24	10	10	9	8	10	10	10	9	10	9	**9.5**	**0.7**	**0.2**	**9.1**	**9.9**
2021	36	8	9	9	7	8	9	9	8	8	9	**8.4**	**0.7**	**0.2**	**8.0**	**8.8**

[a] Lower CI = Lower 95% Confidence Interval, Upper CI = Upper 95% Confidence Interval

[b] HL = Lost as a result of Hurricane Lane (August 22 - 26, 2018)

Appendix A: MTU Final Outdoor Exposure Test Results (2/2021

2. E16 – Above Ground Lap Joint

Michigan Technological University
College of Forest Resources and Environmental Science

Matt Aro
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Duluth, MN 55811

April 14, 2021

Dear Matt,

This letter serves as an extra report for Project E48057A, **Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E16).** The lap joints were evaluated on February 9, 2021 at the Michigan Tech Wood Protection Group (WPG) Kipuka Field Test Site near Hilo, HI. Kipuka site characteristics, climate data during the exposure period, and the test exposure history are included in Appendix A. Above ground decay test data is summarized in Figures 1 and 2 and tabulated data is attached as Appendix B.

Decay Blocks (48 Months, Evaluation 4 of 4 for Current Agreement)

The Natural Resources Research Institute at the University of Minnesota at Duluth (NRRI) prepared lap joints from four deciduous and three conifer species. The hardwoods are yellow poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), white ash (*Fraxinus americana*), and aspen (*Populus tremuloides*). Each of these species was modified by thermal treatment at 170°C or 180°C. Balsam fir (*Abies balsamea*) was also subjected to the thermal treatments. Ponderosa (*Pinus ponderosa*) and southern (*Pinus* spp.) were prepared, without thermal treatment as benchmarks. The lap joints were shipped to the WPG in Houghton, MI for additional processing.

Synergies between DOT and thermal treatment were tested using yellow poplar and red maple. Lap joints were pressure-treated with the recommended above ground retention for southern pine (4.5 kg/m^3) and sorted into two groups. One group was used as the DOT benchmark. The other group was sent to NRRI for thermal modification at 170°C and returned to WPG for the test. Southern pine was pressure-treated to a target retention of 1.0 kg/m^3, 2.0 kg/m^3, or 4.0 kg/m^3 with ACQ-C.[1] Ponderosa pine was dip-treated for three minutes using Woodtreat Millwork®[2] at a 4 to 1 dilution of the concentrate with water. After these treatments were completed, all lap joints were uniquely labelled using stainless steel ID tags and fasteners.

[1] Current Version: AWPA Standard P28-14, *Standard for Alkaline Copper Quat Type C (ACQ-C)*, American Wood Protection Association (2020) Birmingham, AL USA.

[2] Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA). The active biocides are 3-Iodoprop-2-yn-1-yl butylcarbamate (IPBC), tebuconazole, and propiconazole.

The field-ready lap joints were shipped to the test site near Hilo, HI, and installed in an AWPA E16[3] decay test during February 2017. Sue French (NRRI) was present and assisted with the installation. They were visually evaluated for decay and insect attack at the times shown in Table A2 (Appendix A). Statistical analysis on the data was performed using JMP Pro 15.[4] At 48 months of field exposure:

A. Untreated Controls: Decay was universally severe among the untreated control lap joints of the wood species that were thermally modified in this study. White ash was the only species with remaining replicates (Figure 1, Tables B1 and B2). All other untreated lap joints had failed due to decay by 48 months of field exposure.

B. Benchmark Treatments: All yellow poplar and red maple lap joints treated with only DOT had failed due to decay by 36 months of field exposure (Figure 2, Tables B1 and B2). Ponderosa pine lap joints treated with WoodTreat Millwork® were also severely decayed. Southern pine lap joints treated with ACQ-C had variable visible decay that spanned minor to severe with an apparent dose response.

C. Thermal Modification (180°C): Thermal modification of lap joints at 180°C improved the decay resistance in this test when compared to their untreated controls (Figure 1, Tables B1 and B2). Although not directly comparable to each other, thermal modification (180°C) these lap joints may impart improved decay resistance compared to WoodTreat Millwork. Only white ash had equivalent decay resistance to southern pine treated with ACQ-C. Direct comparisons using ponderosa pine and southern pine would be useful.

D. Thermal Modification (170°C): Thermal modification at 170°C did not significantly improve the decay resistance of any of the wood species in this test. Among these lap joints, all remaining replicates of red maple failed due to decay during this evaluation. The remaining replicates of the other species had mostly severe decay. All lap joint types modified only by thermal treatment at 170°C had lower decay resistance than lap joints thermally modified at 180°C, southern pine lap joints treated at all retentions of ACQ-C, or ponderosa pine treated with Woodtreat Millwork (Table B1).

E. Thermal Modification (170°C) + DOT: There was an apparent synergy between the DOT and thermal (170°C) treatments. This combination of treatment appears to be more effective than either of the treatments by itself. Lap joints that were thermally modified at 170°C and treated with DOT had equivalent decay resistance with those thermally modified at 180°C.

F. Insect Attack: There was variable, non-termite, insect attack among the lap joints.

[3] Current Version: AWPA Standard E16-16 *Standard Field Test for Evaluation of Wood Preservatives to be Used Above Ground (UC3B); Horizontal Lap Joint Test*, American Wood Protection Association (2020) Birmingham, AL USA.
[4] JMP Pro 15 (2019) SAS Institute Inc., Cary NC, USA

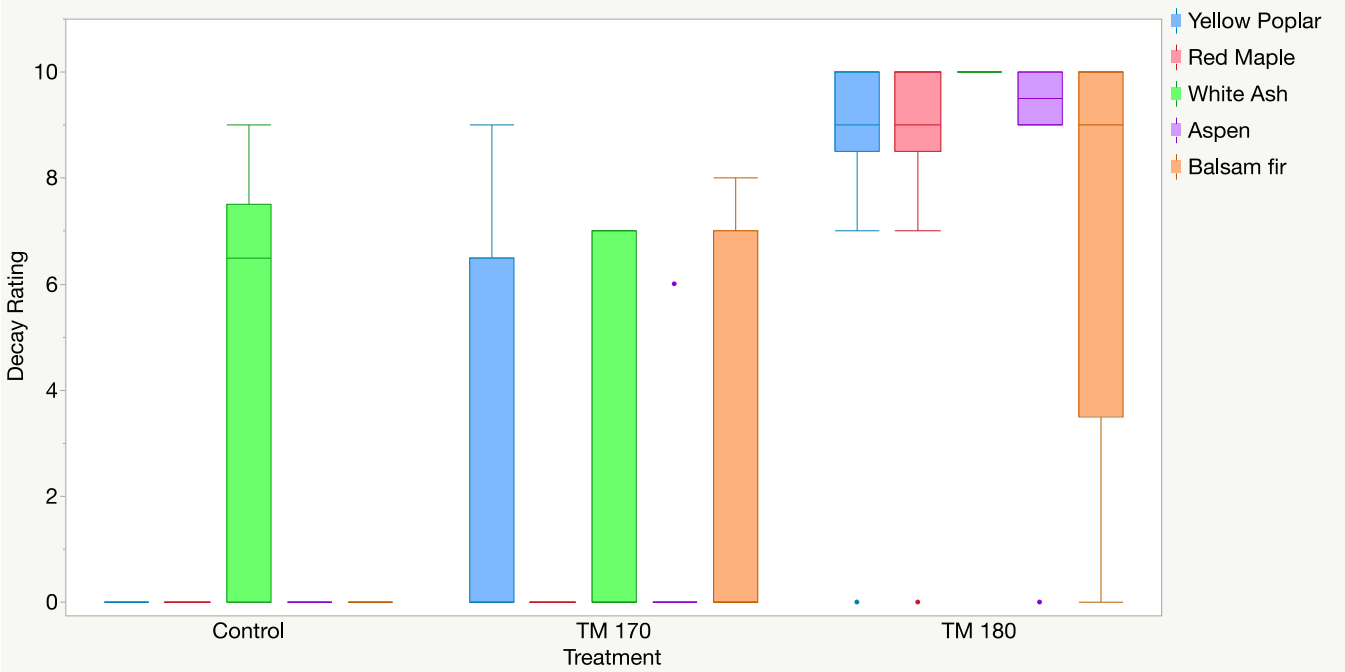

Figure 1. Box plot showing the effect of thermal modification at 170°C (TM 170) or 180°C (TM 180) on the decay resistance of wood after it has been exposed in an AWPA E16 decay test at the WPG Kipuka Field Test Site near Hilo, HI, for a period of 48 months. The dots indicate outliers. When the minimum or maximum value are not part of the box or an outlier, they are indicated by the whiskers. Lines dividing the inside of the boxes are medians. In this instance some medians are equal to the first or third quantiles that define the lower and upper box borders.

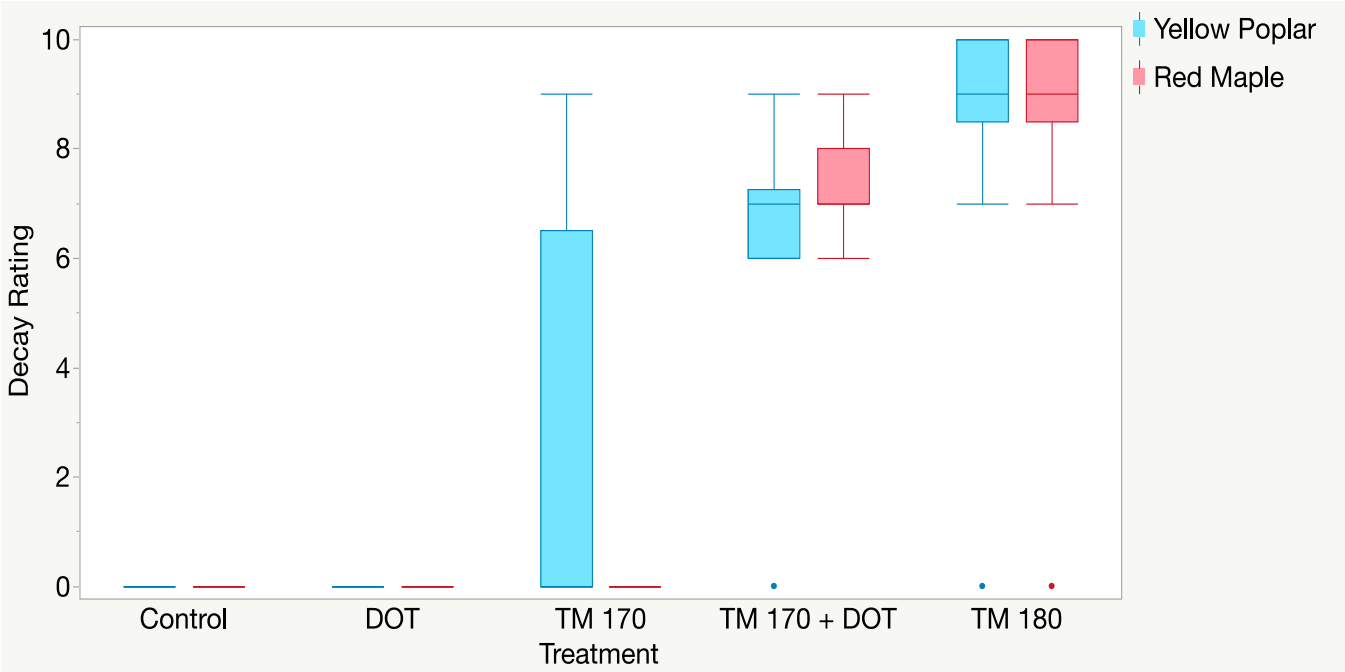

Figure 2. Box plot showing the effect of DOT and/or thermal modification at 170°C (TM 170 + DOT) on the decay resistance of yellow poplar and red maple exposed in an AWPA E16 decay test at the WPG Kipuka Field Test Site near Hilo, HI, for a period of 48 months. The dots indicate outliers. When the minimum or maximum value are not part of the box or an outlier, they are indicated by the whiskers. Lines dividing the inside of the boxes are medians. In this instance the medians are equal to the first or third quantiles that define the lower and upper box borders.

This was the last agreed upon evaluation for project E48057A. Continued evaluations or follow-up tests should be considered. The data in this and other related field tests[5] at the WPG Kipuka Field Test Site shows potential for long-term durability of some species of thermally modified wood treated at 180°C in exterior above ground applications corresponding to AWPA UC3.[6] This would include end uses such as coated millwork and siding (UC3A) or decking and fence pickets (UC3B). However, more testing is needed to confirm these applications as appropriate uses for the thermally modified wood.

We welcome your questions or comments. I may be reached by telephone at (906) 487-3316 or e-mail at gmlarkin@mtu.edu. Dr. Xinfeng Xie, WPG Group Leader, may be reached at (906) 487-2294 or xinfengx@mtu.edu.

Yours truly,

Glenn M. Larkin

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Sr. Research Scientist
Wood Protection Group

Cc: File: E48057A

[5] Project E48057B, *Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E18)*; and Project E48057C, *Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E9)*

[6] AWPA Standard U1-20, *Use Category System: User Specifications for Treated Wood*, American Wood Protection Association (2020) Birmingham, AL USA.

Appendix A: Test Site Information and Project Exposure History

Table A1. Summary of WPG Kipuka Field Test Site Characteristics

Test Site	Location	Climate Station	Station Number	Mean Annual Precipitation	Mean Annual Temperature	Scheffer Index	Soil Type	Known Fungi*		Known Insects*	
Kipuka	Kea'au, HI (USA)	Hilo Int'l Airport	511492	3220 mm 127"	23°C 74°F	330	Silty Clay Loam Hilo Series	*Alternaria* spp.	Mold / Soft Rot	*Xylocopa* spp.	Carpenter Bee
								Antrodia vaillantii	Brown Rot		
								Antrodia xantha	Brown Rot		
								Cladosporium spp.	Mold / Soft Rot		
								Coniophora spp.	Brown Rot		
								Curvularia spp.	Mold / Soft Rot		
								Dacrymyces spp.	Brown Rot		
								Epicoccum spp.	Mold / Soft Rot		
								Fusarium spp.	Mold / Soft Rot		
								Hyphoderma spp.	White Rot		
								Neolentinus lepideus	Brown Rot		
								Paecilomyces spp.	Mold / Soft Rot		
								Penicillium spp.	Mold / Soft Rot		
								Perenniporia tephropora	White Rot		
								Phanaerochaete spp.	White Rot		
								Pleurotus ostreatus	White Rot		
								Pycnoporus cinnabarinus	White Rot		
								Sistotrema spp.	Brown Rot		
								Trichoderma spp.	Mold / Soft Rot		

*Isolated or observed by WPG

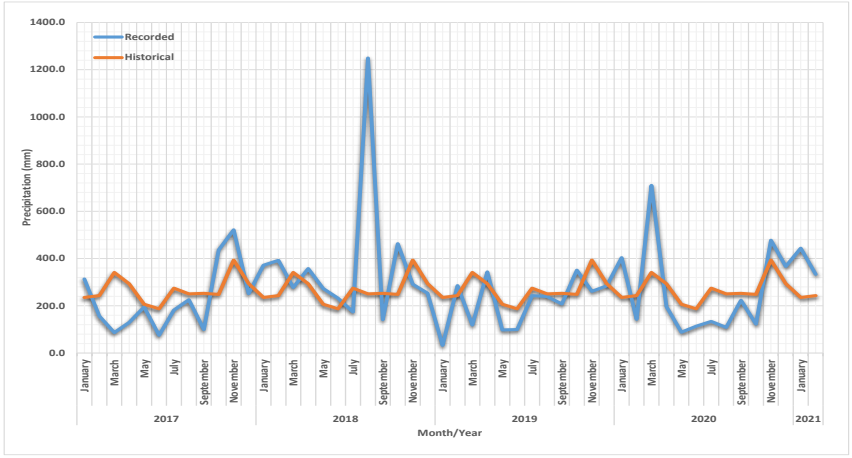

Figure A1. Measured (blue) and mean historical (red) monthly precipitation at the WPG Kipuka Field Test Site (red) during the field exposure.

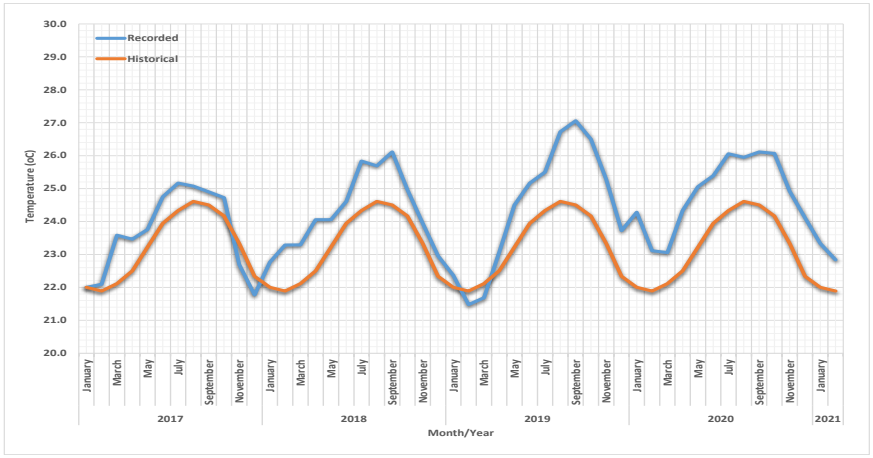

Figure A2. Measured mean (blue) and mean historical (red) monthly temperature at the WPG Kipuka Field Test Site (red) during the field exposure.

Table A2. Exposure and Inspection History of Specimens Exposed in an AWPA E16 Test at the WPG Kipuka Field Test Site near Hilo, HI

Test Site	Project#	Project Name	Test Method	WPG SOP	Specimen Type	Installation/Renewal Date	Inspection Date
Kipuka	E48057A	Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (AWPA E16)	AWPA E16	530	Lap Joints	January 2017	
	48						Feb' 2021
	36						Feb' 2020
	24						Feb' 2019
	12						Feb' 2018

Appendix B: Above Ground Decay Test Data

Table B1. Mean Visual Ratings for Thermally Modified Wood Exposed in an AWPA E16 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057A)

	Type	1	2	3	4	5	6	7	8	9	10	11	12	13
	Species	Yellow Poplar					Red Maple					White Ash		
Lap Joints	Thermal Modification (°C)	180	170	170	N/A	N/A	180	170	170	N/A	N/A	180	170	N/A
	Preservative System	N/A		DOT[a]	DOT	N/A			DOT	DOT	N/A			
	Target Retention (kg/m^3)			4.5	4.5				4.5	4.5				
February	Exposure (Months)	Mean Decay Rating												
2017	0	Installed												
2018	12	10	9.3	9.8	8.9	8.3	10	9.0	9.9	9.5	7.4	10	9.5	9.6
2019	24	9.7	8.2	9.1	7.0	5.4	9.5	8.1	9.4	7.0	5.7	10	9.1	8.2
2020	36	9.0	5.9	8.5	3.7	0.0	8.8	2.1	9.1	4.4	0.0	10	6.2	7.4
2021	48	8.2	3.1	6.4	0.0	0.0	8.2	0.0	7.4	0.0	0.0	10	3.0	4.5
February	Exposure (Months)	Mean Insect Rating												
2017	0	Installed												
2018	12	9.9	10	10	10	9.9	10	10	10	10	10	10	10	10
2019	24	9.9	9.7	9.9	9.4	8.6	10	9.2	10	9.0	9.0	10	9.8	9.7
2020	36	9.8	8.6	9.4	6.7	4.7	9.9	7.8	9.6	7.4	7.1	10	8.4	9.2
2021	48	9.4	6.0	8.2	3.3	0.0	9.4	3.3	8.5	3.1	DF	10	6.1	7.7

Table B1. Mean Visual Ratings for Thermally Modified Wood Exposed in an AWPA E16 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057A) - *Continued*

	Type	14	15	16	17	18	19	20	21	22	23	24
	Species	Balsam Fir			Ponderosa Pine	Southern Pine				Aspen		
Lap Joints	Thermal Modification (°C)	180	170	N/A						180	170	N/A
	Preservative System	N/A			WoodTreat Millwork[a]	ACQ-C[a]			N/A			
	Target Retention (kg/m^3)				0.21	1.0	2.0	4.0				
February	Exposure (Months)	Mean Decay Rating										
2017	0	Installed										
2018	12	9.7	9.6	8.1	9.9	9.3	10	10	9.7	9.9	9.1	8.2
2019	24	9.8	8.7	3.6	9.4	7.3	10	10	7.1	9.8	6.2	3.5
2020	36	8.6	4.2	0.0	7.4	5.4	9.9	10	5.1	10	2.9	0.0
2021	48	7.2	2.9	0.0	5.8	5.0	9.8	10	1.9	8.6	0.7	0.0
February	Exposure (Months)	Mean Insect Rating										
2017	0	Installed										
2018	12	10	9.9	9.5	10	10	10	10	10	10	10	9.7
2019	24	10	9.3	8.6	10	9.7	10	10	9.8	10	9.4	8.6
2020	36	9.9	8.9	8.0	9.6	9.1	10	10	8.7	10	8.6	7.6
2021	48	8.9	7.0	DF	9.1	8.7	9.9	10	7.6	9.7	7.7	DF

[a] DOT = disodium octaborate tetrahydrate, ACQ-C = Ammoniacal Copper Quat Type C, Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA)

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E16 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057A)

Type	Species	Yellow Poplar		Thermal Modification (°C)			180	Preservative System		N/A		Target Retention (kg/m³)			N/A	
1	"P" Series	6801	6802	6803	6804	6805	6806	6807	6808	6809	6810	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI[a]	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	9	9	10	10	10	10	9	10	10	9.7	0.5	0.2	9.4	10
2020	36	10	10	0	10	10	10	10	10	10	10	9.0	3.2	1.0	7.0	10
2021	48	7	9	0	9	9	9	10	10	9	10	8.2	3.0	1.0	6.3	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	9	10	10	9.9	0.3	0.1	9.7	10
2019	24	10	10	10	10	10	10	10	9	10	10	9.9	0.3	0.1	9.7	10
2020	36	10	10	8	10	10	10	10	10	10	10	9.8	0.6	0.2	9.4	10
2021	48	8	9	DF	10	9	9	10	10	10	10	9.4	0.7	0.2	9.0	9.9

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E16 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057A) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			170	Preservative System		N/A		Target Retention (kg/m³)			N/A	
2	"P" Series	6811	6812	6813	6814	6815	6816	6817	6818	6819	6820	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	9	10	10	8	8	10	9	9	9.3	0.8	0.3	8.8	9.8
2019	24	10	9	9	9	7	7	9	HL[e]	7	7	8.2	1.2	0.4	7.4	9.0
2020	36	10	6	7	10	0	0	8	HL	4	8	5.9	3.8	1.3	3.4	8.4
2021	48	9	6	0	7	0	0	0	HL	0	6	3.1	3.8	1.3	0.6	5.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	9	9	10	HL	9	10	9.7	0.5	0.2	9.3	10
2020	36	10	8	9	10	8	8	10	HL	6	8	8.6	1.3	0.4	7.7	9.4
2021	48	10	7	0	7	DF	DF	7	HL	4	7	6.0	3.2	1.2	3.7	8.3

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			170	Preservative System		DOT[b]		Target Retention (kg/m³)			4.5	
3	"P" Series	6821	6822	6823	6824	6825	6826	6827	6828	6829	6830	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	8	10	10	10	10	10	10	10	9.8	0.6	0.2	9.4	10
2019	24	9	8	10	9	9	8	9	10	9	10	9.1	0.7	0.2	8.6	9.6
2020	36	10	8	9	10	9	8	7	8	8	8	8.5	1.0	0.3	7.9	9.1
2021	48	9	6	7	7	7	7	0	6	7	8	6.4	2.4	0.8	4.9	7.9
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	9	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	10	9	10	10	10	9	8	8	10	10	9.4	0.8	0.3	8.9	9.9
2021	48	10	7	8	9	8	8	7	8	8	9	8.2	0.9	0.3	7.6	8.8

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			N/A	Preservative System		DOT		Target Retention (kg/m³)			4.5	
4	"P" Series	6831	6832	6833	6834	6835	6836	6837	6838	6839	6840	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	8	9	10	9	8	10	8	9	9	8.9	0.7	0.2	8.4	9.4
2019	24	6	8	8	7	8	4	8	8	7	6	7.0	1.3	0.4	6.2	7.8
2020	36	0	8	4	7	0	4	7	0	0	7	3.7	3.4	1.1	1.6	5.8
2021	48	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	8	9	10	10	10	8	10	10	10	9	9.4	0.8	0.3	8.9	9.9
2020	36	0	8	7	9	7	7	8	7	6	8	6.7	2.5	0.8	5.2	8.2
2021	48	DF	6	0	0	DF	0	7	DF	DF	7	3.3	3.7	1.5	0.4	6.3

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)			N/A	
5	"P" Series	6841	6842	6843	6844	6845	6846	6847	6848	6849	6850	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	9	8	6	10	8	8	9	8	8	8.3	1.1	0.3	7.6	9.0
2019	24	7	8	4	0	7	6	7	7	4	4	5.4	2.4	0.8	3.9	6.9
2020	36	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
2021	48	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	9	9.9	0.3	0.1	9.7	10
2019	24	9	9	8	10	9	8	9	10	7	7	8.6	1.1	0.3	7.9	9.3
2020	36	0	7	7	DF	6	6	0	6	4	6	4.7	2.8	0.9	2.8	6.5
2021	48	0	DF	DF	DF	DF	DF	DF	DF	DF	DF	0.0	DF	DF	DF	DF

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			180	Preservative System		N/A		Target Retention (kg/m³)			N/A	
6	"P" Series	6851	6852	6853	6854	6855	6856	6857	6858	6859	6860	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	9	9	9	10	10	9	10	10	10	9	9.5	0.5	0.2	9.2	10
2020	36	10	10	10	9	10	9	10	10	10	0	8.8	3.1	1.0	6.9	10
2021	48	9	7	10	9	9	10	9	9	10	0	8.2	3.0	1.0	6.3	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	9	9.9	0.3	0.1	9.7	10
2021	48	9	9	10	9	10	10	9	9	10	DF	9.4	0.5	0.2	9.1	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			170	Preservative System		N/A		Target Retention (kg/m³)			N/A	
7	"P" Series	6861	6862	6863	6864	6865	6866	6867	6868	6869	6870	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	8	9	9	9	9	9	9	9	10	9.0	0.5	0.1	8.7	9.3
2019	24	7	8	7	8	9	8	9	8	9	8	8.1	0.7	0.2	7.6	8.6
2020	36	0	0	6	M	0	0	0	0	6	7	2.1	3.2	1.1	0.0	4.2
2021	48	0	0	0	M	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	8	9	8	8	10	10	9	10	10	10	9.2	0.9	0.3	8.6	9.8
2020	36	8	8	8	M	8	7	8	7	8	8	7.8	0.4	0.1	7.5	8.1
2021	48	DF	DF	0	M	DF	DF	DF	DF	6	4	3.3	3.1	1.8	0.0	6.8

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			170	Preservative System		DOT		Target Retention (kg/m³)			4.5	
8	"P" Series	6871	6872	6873	6874	6875	6876	6877	6878	6879	6880	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2019	24	9	10	9	10	8	10	10	10	10	8	9.4	0.8	0.3	8.9	9.9
2020	36	8	10	8	8	9	10	10	10	9	9	9.1	0.9	0.3	8.6	9.6
2021	48	7	8	6	7	9	7	7	7	8	8	7.4	0.8	0.3	6.9	7.9
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	8	10	8	10	10	10	10	10	10	10	9.6	0.8	0.3	9.1	10
2021	48	8	8	7	8	10	8	10	7	9	10	8.5	1.2	0.4	7.8	9.2

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			N/A	Preservative System		DOT		Target Retention (kg/m³)			4.5	
9	"P" Series	6881	6882	6883	6884	6885	6886	6887	6888	6889	6890	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	9	10	9	10	10	10	8	9.5	0.7	0.2	9.1	10
2019	24	7	8	7	6	7	8	8	7	8	4	7.0	1.2	0.4	6.2	7.8
2020	36	4	7	6	4	0	6	4	6	7	0	4.4	2.6	0.8	2.8	6.0
2021	48	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	9	9	8	8	10	9	9	10	8	9.0	0.8	0.3	8.5	9.5
2020	36	8	8	8	8	6	8	8	8	8	4	7.4	1.3	0.4	6.6	8.2
2021	48	4	7	0	4	DF	0	0	4	6	DF	3.1	2.8	1.0	1.2	5.1

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m³)				N/A
10	"P" Series	6891	6892	6893	6894	6895	6896	6897	6898	6899	6900	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	7	7	7	7	10	7	7	7	8	7	7.4	1.0	0.3	6.8	8.0
2019	24	0	6	7	6	8	6	7	6	7	4	5.7	2.3	0.7	4.3	7.1
2020	36	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
2021	48	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	8	7	10	8	10	8	10	10	10	9	9.0	1.2	0.4	8.3	9.7
2020	36	DF	7	6	7	8	4	7	9	9	7	7.1	1.5	0.5	6.1	8.1
2021	48	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m³)				N/A
11	"P" Series	6901	6902	6903	6904	6905	6906	6907	6908	6909	6910	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m³)				N/A
12	"P" Series	6911	6912	6913	6914	6915	6916	6917	6918	6919	6920	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	9	10	9	9	10	9	10	9.5	0.5	0.2	9.2	9.8
2019	24	8	10	8	10	9	8	10	10	9	9	9.1	0.9	0.3	8.6	9.6
2020	36	8	M	0	7	8	7	8	10	8	0	6.2	3.6	1.2	3.8	8.6
2021	48	0	M	0	0	6	7	7	0	7	0	3.0	3.6	1.2	0.7	5.3
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	8	M	8	8	8	8	10	10	8	8	8.4	0.9	0.3	7.9	9.0
2021	48	6	M	DF	0	8	7	7	8	7	DF	6.1	2.8	1.1	4.1	8.2

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m³)				N/A
13	"P" Series	6921	6922	6923	6924	6925	6926	6927	6928	6929	6930	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	10	8	10	9	10	10	10	10	10	9.6	0.7	0.2	9.2	10
2019	24	8	8	6	8	9	9	9	9	7	9	8.2	1.0	0.3	7.6	8.8
2020	36	7	9	7	8	0	10	7	8	8	10	7.4	2.8	0.9	5.6	9.2
2021	48	0	7	0	9	0	9	0	6	7	7	4.5	4.0	1.3	2.0	7.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	8	10	10	10	10	10	9	10	9.7	0.7	0.2	9.3	10
2020	36	9	10	7	10	8	10	10	8	10	10	9.2	1.1	0.4	8.5	9.9
2021	48	7	8	4	10	DF	10	7	7	8	8	7.7	1.8	0.6	6.5	8.8

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m³)				N/A
14	"P" Series	6931	6932	6933	6934	6935	6936	6937	6938	6939	6940	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	10	10	8	10	10	10	10	10	10	9.7	0.7	0.2	9.3	10
2019	24	9	10	10	9	10	10	10	10	10	10	9.8	0.4	0.1	9.5	10
2020	36	6	M	9	6	7	10	9	10	10	10	8.6	1.7	0.6	7.4	9.7
2021	48	7	M	9	0	0	10	9	10	10	10	7.2	4.2	1.4	4.5	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	M	10	9	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2021	48	7	M	9	7	8	10	9	10	10	10	8.9	1.3	0.4	8.1	9.7

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m³)				N/A
15	"P" Series	6941	6942	6943	6944	6945	6946	6947	6948	6949	6950	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	8	9	10	10	10	10	9	9.6	0.7	0.2	9.2	10
2019	24	8	HL	8	10	10	7	9	9	8	9	8.7	1.0	0.3	8.0	9.3
2020	36	0	HL	0	7	8	7	0	9	7	0	4.2	4.1	1.4	1.6	6.9
2021	48	0	HL	0	7	8	0	0	7	4	0	2.9	3.6	1.2	0.5	5.2
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	9	10	10	10	10	0.3	0.1	9.7	10
2019	24	9	HL	8	10	10	9	10	10	8	10	9.3	0.9	0.3	8.8	9.9
2020	36	8	HL	8	10	9	8	9	10	8	10	8.9	0.9	0.3	8.3	9.5
2021	48	DF	HL	DF	8	9	6	DF	8	4	DF	7.0	2.0	0.9	5.2	8.8

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m^3)				N/A
16	"P" Series	6951	6952	6953	6954	6955	6956	6957	6958	6959	6960	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										**10**	**0.0**	**0.0**	**10**	**10**
2018	12	8	6	9	7	8	8	9	8	9	9	**8.1**	**1.0**	**0.3**	**7.5**	**8.7**
2019	24	0	6	6	6	0	0	8	4	6	0	**3.6**	**3.2**	**1.0**	**1.6**	**5.6**
2020	36	0	M	0	0	0	0	M	0	0	0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
2021	48	0	M	0	0	0	0	M	0	0	0	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										**10**	**0.0**	**0.0**	**10**	**10**
2018	12	10	8	10	8	9	10	10	10	10	10	**9.5**	**0.8**	**0.3**	**9.0**	**10**
2019	24	9	8	9	8	8	8	10	9	9	8	**8.6**	**0.7**	**0.2**	**8.2**	**9.0**
2020	36	DF	M	10	8	DF	DF	M	7	7	DF	**8.0**	**1.4**	**0.7**	**6.6**	**9.4**
2021	48	DF	M	DF	DF	DF	DF	M	DF	DF	DF	**DF**	**DF**	**DF**	**DF**	**DF**

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Ponderosa Pine		Thermal Modification (°C)			N/A	Preservative System		WoodTreat Millwork[b]		Target Retention (kg/m³)				0.21
17	"P" Series	6961	6962	6963	6964	6965	6966	6967	6968	6969	6970	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	9	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2019	24	10	9	10	10	9	8	10	10	8	10	9.4	0.8	0.3	8.9	9.9
2020	36	9	0	8	10	10	10	10	M	0	10	7.4	4.3	1.4	4.7	10
2021	48	10	0	8	0	9	9	9	M	0	7	5.8	4.4	1.5	2.9	8.7
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	8	10	10	10	10	10	M	8	10	9.6	0.9	0.3	9.0	10
2021	48	10	DF	9	7	10	10	10	M	DF	8	9.1	1.2	0.5	8.2	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C[b]		Target Retention (kg/m³)				1.0
18	"P" Series	6991	6992	6993	6994	6995	6996	6997	6998	6999	7000	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	9	9	10	9	9	10	9	9	10	9.3	0.5	0.2	9.0	9.6
2019	24	6	7	9	9	0	9	9	HL	9	8	7.3	3.0	1.0	5.4	9.3
2020	36	0	8	8	8	0	8	8	HL	9	0	5.4	4.1	1.4	2.8	8.1
2021	48	0	7	7	7	0	8	7	HL	9	0	5.0	3.8	1.3	2.5	7.5
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	9	10	10	8	10	10	HL	10	10	9.7	0.7	0.2	9.2	10
2020	36	8	10	8	10	DF	9	10	HL	10	8	9.1	1.0	0.4	8.4	9.8
2021	48	DF	9	8	8	DF	9	8	HL	10	DF	8.7	0.8	0.3	8.0	9.3

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C		Target Retention (kg/m³)				2.0
19	"P" Series	6981	6982	6983	6984	6985	6986	6987	6988	6989	6990	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	9	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2021	48	10	10	9	10	10	10	9	10	10	10	9.8	0.4	0.1	9.5	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	10	10	9	10	10	10	9.9	0.3	0.1	9.7	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C		Target Retention (kg/m³)			4.0	
20	"P" Series	6971	6972	6973	6974	6975	6976	6977	6978	6979	6980	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)			N/A	
21	"P" Series	7001	7002	7003	7004	7005	7006	7007	7008	7009	7010	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	9	10	9	9	9.7	0.5	0.2	9.4	10
2019	24	7	HL	8	9	9	HL	8	9	0	7	7.1	3.0	1.1	5.0	9.2
2020	36	0	HL	10	8	8	HL	0	8	0	7	5.1	4.3	1.5	2.1	8.1
2021	48	0	HL	7	0	8	HL	0	0	0	0	1.9	3.5	1.2	0.0	4.3
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	9	HL	10	10	10	HL	9	10	10	10	9.8	0.5	0.2	9.4	10
2020	36	8	HL	10	8	10	HL	8	9	DF	8	8.7	1.0	0.4	8.0	9.4
2021	48	DF	HL	8	8	8	HL	DF	8	DF	6	7.6	0.9	0.4	6.8	8

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			180	Preservative System		N/A		Target Retention (kg/m³)			N/A	
22	"P" Series	7011	7012	7013	7014	7015	7016	7017	7018	7019	7020	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	9	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2019	24	10	10	10	10	10	9	9	10	10	10	9.8	0.4	0.1	9.5	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	10	9	9	0	9	9	8.6	3.1	1.0	6.7	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	10	10	10	8	10	9	9.7	0.7	0.2	9.3	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			170	Preservative System		N/A		Target Retention (kg/m³)			N/A	
23	"P" Series	7021	7022	7023	7024	7025	7026	7027	7028	7029	7030	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	9	10	9	9	10	9	8	8	10	9.1	0.7	0.2	8.6	9.6
2019	24	6	9	9	7	8	9	HL	0	0	8	6.2	3.7	1.2	3.8	8.6
2020	36	0	0	0	7	9	10	HL	0	0	0	2.9	4.4	1.5	0.0	5.8
2021	48	0	0	0	0	0	6	HL	0	0	0	0.7	2.0	0.7	0.0	2.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	9	10	HL	8	8	10	9.4	0.9	0.3	8.9	10
2020	36	8	8	8	8	10	10	HL	DF	DF	8	8.6	1.0	0.4	7.8	9.3
2021	48	DF	DF	DF	8	7	8	HL	DF	DF	DF	7.7	0.6	0.3	7.0	8.3

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E18 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057B) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)			N/A	
24	"P" Series	7031	7032	7033	7034	7035	7036	7037	7038	7039	7040	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	8	9	8	10	9	8	7	7	7	8.2	1.0	0.3	7.6	8.8
2019	24	7	8	7	0	6	0	7	0	0	0	3.5	3.7	1.2	1.2	5.8
2020	36	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
2021	48	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	9	8	9.7	0.7	0.2	9.3	10
2019	24	8	10	10	7	10	10	10	8	6	7	8.6	1.6	0.5	7.6	9.6
2020	36	7	7	8	DF	9	DF	7	DF	DF	DF	7.6	0.9	0.4	6.8	8.4
2021	48	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF	DF

[a] Lower CI = Lowe 95% Confidence Interval, Upper CI = Upper 95% Confidence Interval

[b] DOT = disodium octaborate tetrahydrate, ACQ-C = Ammoniacal Copper Quat Type C, Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA)

[c] HL = Lost as a result of Hurricane Lane (August 22 - 26, 2018)

Michigan Technological University
College of Forest Resources and Environmental Science

Matt Aro
Natural Resources Research Institute
5013 Miller Trunk Highway
Duluth, MN 55811

April 14, 2021

Dear Matt,

This letter serves as the final report for Project WPG180122A, **Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E16 - Add On).** The lap joints were evaluated on February 9, 2021 at the Michigan Tech Wood Protection Group (WPG) Kipuka Field Test Site near Hilo, HI. Kipuka site characteristics, climate data during the exposure period, and the test exposure history are included in Appendix A. Above ground decay test data is presented in Appendix B.

Lap Joints (36 Months, Evaluation 3 of 3 for Current Contract)

The Natural Resources Research Institute at the University of Minnesota at Duluth (NRRI) prepared longitudinal lap joints for eastern hemlock (*Tsuga canadensis*) then modified them by thermal treatment at 170°C or 180°C. Southern (*Pinus* spp.) was prepared, without thermal treatment as a control. The lap joints were shipped to the WPG in Houghton, MI, where each was assembled and uniquely labelled using stainless steel ID tags and fasteners.

The field-ready lap joints were shipped to the test site near Hilo, HI, and installed in an AWPA E16[1] decay test during February 2018. They were visually evaluated for decay and insect attack as shown in Table A2 (Appendix A). At 36 months of field exposure:

A. Untreated Controls: There was variable visible decay among the untreated eastern hemlock and southern pine lap joints. Each wood species had two failures due to decay during this evaluation.

B. Thermal Modification: Test results seem to indicate that thermal modification at 170°C or 180°C may improve the decay resistance of eastern hemlock in this test, compared to the controls. Thermal modification at both temperatures had equivalent decay resistance.

This was the last contracted evaluation for project WPG160122A. You may want to consider continuing evaluations. More time is needed to determine the long-term decay resistance of eastern hemlock after

[1] Current Version: AWPA Standard E16-16 *Standard Field Test for Evaluation of Wood Preservatives to be Used Above Ground (UC3B); Horizontal Lap Joint Test*, American Wood Protection Association (2020) Birmingham, AL USA.

thermal modification at the treatment conditions used for this test. There has not been sufficient field exposure for a definitive test.

We welcome your questions or comments. I may be reached by telephone at (906) 487-3316 or e-mail at gmlarkin@mtu.edu. Dr. Xinfeng Xie, WPG Group Leader, may be reached at (906) 487-2294 or xinfengx@mtu.edu.

Yours truly,

Glenn M. Larkin

Glenn M. Larkin
Sr. Research Scientist
Wood Protection Group

Cc: File: WPG180122A

Appendix A: Test Site Information and Project Exposure History

Table A1. Summary of WPG Kipuka Field Test Site Characteristics

Test Site	Location	Climate Station	Station Number	Mean Annual Precipitation		Mean Annual Temperature		Scheffer Index	Soil Type		Known Fungi*		Known Insects*	
Kipuka	Kea'au, HI (USA)	Hilo Int'l Airport	511492	3220 mm	127"	23^{0}C	74^{0}F	330	Silty Clay Loam	Hilo Series	*Alternaria* spp.	Mold / Soft Rot	*Xylocopa* spp.	Carpenter Bee
											Antrodia vaillantii	Brown Rot		
											Antrodia xantha	Brown Rot		
											Cladosporium spp.	Mold / Soft Rot		
											Coniophora spp.	Brown Rot		
											Curvularia spp.	Mold / Soft Rot		
											Dacrymyces spp.	Brown Rot		
											Epicoccum spp.	Mold / Soft Rot		
											Fusarium spp.	Mold / Soft Rot		
											Hyphoderma spp.	White Rot		
											Neolentinus lepideus	Brown Rot		
											Paecilomyces spp.	Mold / Soft Rot		
											Penicillium spp.	Mold / Soft Rot		
											Perenniporia tephropora	White Rot		
											Phanaerochaete spp.	White Rot		
											Pleurotus ostreatus	White Rot		
											Pycnoporus cinnabarinus	White Rot		
											Sistotrema spp.	Brown Rot		
											Trichoderma spp.	Mold / Soft Rot		

*Isolated or observed by WPG

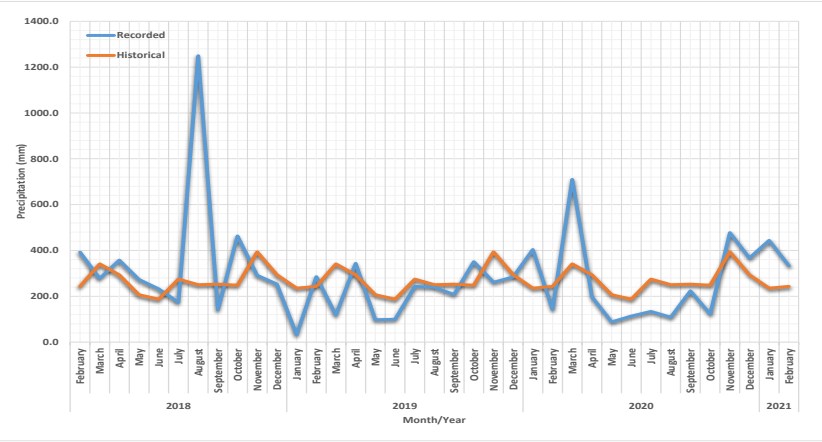

Figure A1. Measured (blue) and mean historical (red) monthly precipitation at the WPG Kipuka Field Test Site (red) during the field exposure.

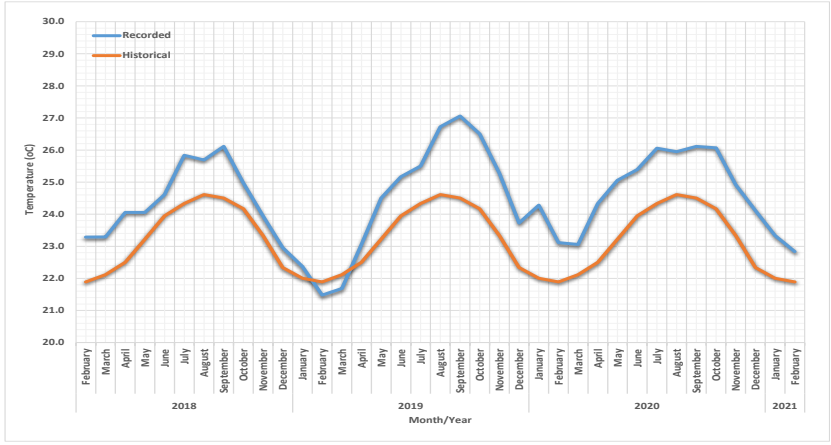

Figure A2. Measured mean (blue) and mean historical (red) monthly temperature at the WPG Kipuka Field Test Site (red) during the field exposure.

Table A2. Exposure and Inspection History of Specimens Exposed in an AWPA E16 Test at the WPG Kipuka Field Test Site near Hilo, HI

Test Site	Project#	Project Name	Test Method	WPG SOP	Specimen Type	Installation/Renewal Date	Inspection Date
Kipuka	WPG180122A	Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (AWPA E16)	AWPA E16	530	Lap Joints	January 2018	
	36						Feb' 2021
	24						Feb' 2020
	12						Feb' 2019

Appendix B: Above Ground Decay Test Data

Table B1. Mean Visual Ratings for Thermally Modified Wood Exposed in an AWPA E16 Test (Project WPG180122B)[a]

Lap Joints	Type	25	26	27	28
	Species	Eastern Hemlock			Southern Pine
	Thermal Modification (^{o}C)	180	170	N/A	N/A
February	Exposure (Months)	Mean Decay Rating			
2018	0	Installed			
2019	12	10	9.8	9.3	9.2
2020	24	9.9	9.6	7.7	7.6
2021	36	9.8	9.2	5.8	6.2
February	Exposure (Months)	Mean Insect Rating			
2018	0	Installed			
2019	12	10	9.9	9.9	10
2020	24	10	10	9.3	9.8
2021	36	9.9	9.6	8.2	7.9

[a] AWPA E16 Test Exposure at the WPG Kipuka Field Test Site near Hilo, HI

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E16 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122A)

Type	Species	Eastern Hemlock		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m³)			N/A
25	"P" Series	8511	8512	8513	8514	8515	8516	8517	8518	8519	8520	Summary Statistics			
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI[a]	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	24	10	10	10	9	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2021	36	10	10	10	10	10	10	8	10	10	10	9.8	0.6	0.2	9.4	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	36	10	10	10	10	10	10	9	10	10	10	9.9	0.3	0.1	9.7	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E16 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122A) - *Continued*

Type	Species	Eastern Hemlock		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m³)			N/A
26	"P" Series	8521	8522	8523	8524	8525	8526	8527	8528	8529	8530	Summary Statistics			
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	9	10	10	10	9	9.8	0.4	0.1	9.5	10
2020	24	10	9	10	10	9	9	10	10	10	9	9.6	0.5	0.2	9.3	10
2021	36	7	10	9	10	10	10	10	10	9	7	9.2	1.2	0.4	8.4	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	9	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	36	10	10	9	10	10	10	10	10	9	8	9.6	0.7	0.2	9.2	10

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E16 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122A) - *Continued*

Type	Species	Eastern Hemlock		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m³)			N/A
27	"P" Series	8531	8532	8533	8534	8535	8536	8537	8538	8539	8540	Summary Statistics			
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	9	9	7	10	9	10	10	9	10	9.3	0.9	0.3	8.7	9.9
2020	24	8	7	8	6	10	8	8	9	6	7	7.7	1.3	0.4	6.9	8.5
2021	36	6	0	4	0	10	8	8	9	6	7	5.8	3.5	1.1	3.6	8.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	9	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	24	9	8	8	8	10	10	10	10	10	10	9.3	0.9	0.3	8.7	10
2021	36	7	6	7	8	10	10	8	9	8	9	8.2	1.3	0.4	7.4	9.0

Table B2. Visual Ratings for Thermally Modified Wood Exposed in an AWPA E16 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122A) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m^3)			N/A	
28	"G" Series	6151	6152	6153	6154	6155	6156	6157	6158	6159	6160	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										**10**	**0.0**	**0.0**	**10**	**10**
2019	12	10	9	9	8	10	10	10	10	8	8	**9.2**	**0.9**	**0.3**	**8.6**	**9.8**
2020	24	7	8	8	8	8	8	7	8	7	7	**7.6**	**0.5**	**0.2**	**7.3**	**7.9**
2021	36	0	8	9	8	0	8	8	7	6	8	**6.2**	**3.4**	**1.1**	**4.1**	**8.3**
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										**10**	**0.0**	**0.0**	**10**	**10**
2019	12	10	10	10	10	10	10	10	10	10	10	**10**	**0.0**	**0.0**	**10**	**10**
2020	24	9	10	10	10	9	10	10	10	10	10	**9.8**	**0.4**	**0.1**	**9.5**	**10**
2021	36	8	9	10	8	0	9	9	9	7	10	**7.9**	**2.9**	**0.9**	**6.1**	**9.7**

[a] Lower CI = Lowe 95% Confidence Interval, Upper CI = Upper 95% Confidence Interval

[b] HL = Lost as a result of Hurricane Lane (August 22 - 26, 2018)

Appendix A: MTU Final Outdoor Exposure Test Results (2/2021

3. E9- Fenestration L-Joint

Michigan Technological University

College of Forest Resources and Environmental Science

Matt Aro
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5013 Miller Trunk Highway
Duluth, MN 55811

April 15, 2021

Dear Matt,

This letter serves as an extra report for Project E48057C, **Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E9).** The L-joints were evaluated on February 11, 2021 at the Michigan Tech Wood Protection Group (WPG) Kipuka Field Test Site near Hilo, HI. Kipuka site characteristics, climate data during the exposure period, and the test exposure history are included in Appendix A. Above ground decay test data is summarized in Figures 1 and 2 and tabulated data is attached as Appendix B.

L-Joints (48 Months, Evaluation 4 of 4 for Current Agreement)

The Natural Resources Research Institute at the University of Minnesota at Duluth (NRRI) prepared L-joints using four deciduous and three conifer species. The hardwoods are yellow poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), white ash (*Fraxinus americana*), and aspen (*Populus tremuloides*). Each of these species was modified by thermal treatment at 170°C or 180°C. Balsam fir (*Abies balsamea*) was also subjected to the thermal treatments. Ponderosa (*Pinus ponderosa*) and southern (*Pinus* spp.) were prepared, without thermal treatment as controls. The L-joints were shipped to the WPG in Houghton, MI for additional processing.

Synergies between DOT and thermal treatment were tested using yellow poplar and red maple. L-joint members were pressure-treated with the recommended above ground retention for southern pine (4.5 kg/m^3) and sorted into two groups. One group was used as the DOT benchmark. The other group was sent to NRRI for thermal modification at 170°C and returned to WPG for the test. Southern pine was pressure-treated to a target retention of 1.0 kg/m^3, 2.0 kg/m^3, or 4.0 kg/m^3 with ACQ-C.[1] Ponderosa pine was dip-treated for three minutes using Woodtreat Millwork®[2] at a 4 to 1 dilution of the concentrate with water.

After these treatments were completed, all L-joints were painted with white exterior latex (Sherwin Williams A100) and the outside ends were sealed with Epoxy King SC110 UV-resistant marine grade

[1] Current Version: AWPA Standard P28-14, *Standard for Alkaline Copper Quat Type C (ACQ-C)*, American Wood Protection Association (2019) Birmingham, AL USA.

[2] Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA). The active biocides are 3-Iodoprop-2-yn-1-yl butylcarbamate (IPBC), tebuconazole, and propiconazole.

epoxy (ResTech Environmental Products, LLC., Addison, TX). After drying, the painted L-joints were assembled and uniquely labelled using stainless steel ID tags and fasteners.

The field-ready L-joints were shipped to the test site near Hilo, HI, and installed in an AWPA E9[3] decay test during February 2017. They were visually evaluated for decay and insect attack at the times shown in Table A2 (Appendix A). Evaluations were performed and reported separately for the mortise and tenon. A combined rating, the lower value of the mortise or tenon, is also reported (Table B1). There was excellent agreement between the L-Joint decay ratings for the mortises and tenons (r = 0.94), therefore the discussion below is based on the combined ratings. Statistical analysis on the data was performed using JMP Pro 15.[4] At 48 months of field exposure:

A. Untreated Controls: Mean decay ratings were universally severe among the untreated control L-joints of the wood species that were thermally modified in this study. Yellow poplar, red maple, and aspen untreated controls had failed or functionally failed due to decay (Figure 1, Table B1). Although severely decayed, the white ash controls had resistance to decay that was greater than the other hardwoods and comparable to balsam fir. High variability among the white ash and balsam fir L-joints from a widespread range of visible decay resulted in statistical equivalence with thermally modified L-joint types within these species.

B. Benchmark Treatments: Yellow poplar and red maple L-joints treated with DOT were severely decayed and had functionally failed due to decay (Figure 2, Tables B1-B5). Ponderosa pine L-joints treated with WoodTreat Millwork® were also severely decayed. Southern pine L-joints treated with ACQ-C had minor to moderate visible decay with a probable dose response.

C. Thermal Modification (180°C): Thermal modification of L-joints at 180°C appeared to improve the decay resistance of the hardwoods in this test when compared to their untreated controls (Figure 1, Tables B1-B5). All the wood species treated with thermal modification at 180°C had mean visible decay ratings above 7. Decay ratings of 7 or less are generally considered as non-serviceable for the intended use of the wood.

   Although not directly comparable to each other, thermal modification (180°C) these L-joints had decay resistance that was generally equivalent to the lower retentions of southern pine L-joints treated with ACQ-C and possible improvement compared to the ponderosa pine treated with WoodTreat Millwork. Direct comparisons using ponderosa pine and southern pine would be useful.

D. Thermal Modification (170°C): Thermal modification at 170°C numerically improved the decay resistance of the wood species in this test compared to their untreated controls. However, all the hardwood L-joint types treated by thermal modification at 170°C experienced severe decay by 36 months of field exposure. These L-joints were generally not decay resistant.

[3] Current Version: AWPA Standard E9-15 *Standard Field Test for Evaluation of Wood Preservatives to be Used Above Ground (UC3A & UC3B); L-Joint Test*, American Wood Protection Association (2020) Birmingham, AL USA.
[4] JMP Pro 15 (2019) SAS Institute Inc., Cary NC, USA

E.

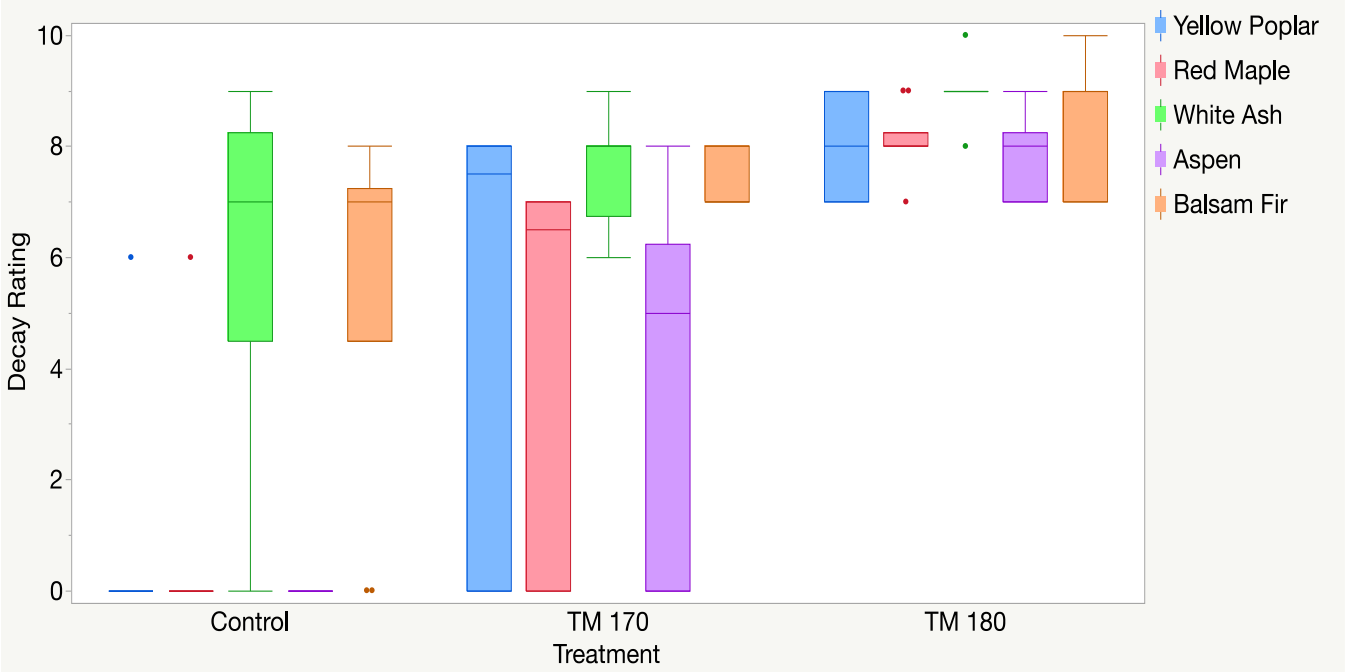

Figure 1. Box plot showing the effect of thermal modification at 170°C (TM 170) or 180°C (TM 180) on the decay resistance of wood after it has been exposed in an AWPA E9 decay test at the WPG Kipuka Field Test Site near Hilo, HI, for a period of 48 months. When the minimum or maximum value are not part of the box or an outlier, they are indicated by the whiskers. Lines dividing the inside of the boxes are medians. In this instance some medians are equal to the first or third quantiles that define the lower and upper box borders. Results are shown for the combined mortise and tenon ratings.

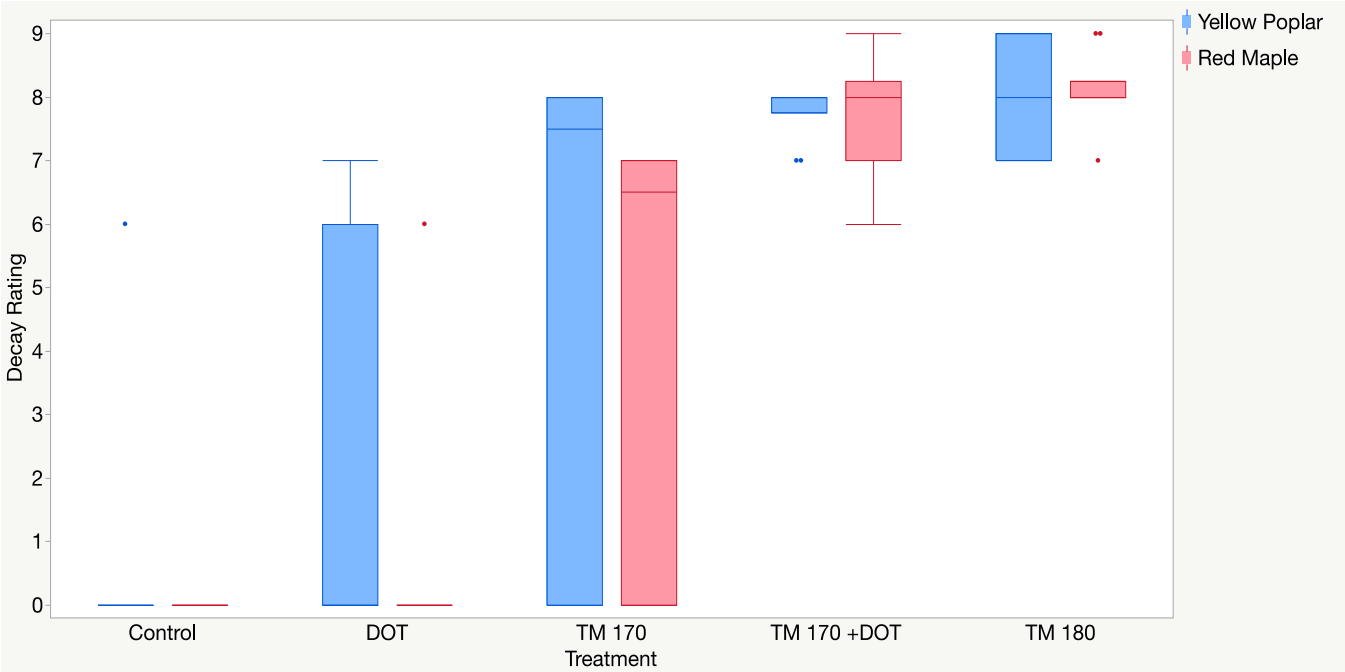

Figure 2. Box plot showing the effect of DOT and/or thermal modification at 170°C (TM 170 + DOT) on the decay resistance of yellow poplar and red maple exposed in an AWPA E9 decay test at the WPG Kipuka Field Test Site near Hilo, HI, for a period of 48 months. The dots indicate outliers. When the minimum or maximum value are not part of the box or an outlier, they are indicated by the whiskers. Lines dividing the inside of the boxes are medians. In this instance the medians are equal to the first or third quantiles that define the lower and upper box borders. Results are shown for the combined mortise and tenon ratings.

All hardwood L-joint types modified by thermal treatment at 170°C had numerically lower mean visible decay resistance than those thermally modified at 180°C, southern pine treated at all retentions of ACQ-C, or ponderosa pine treated with Woodtreat Millwork (Table B1). Yellow poplar L-joints treated with heat at 170°C or 180°C had statistically equivalent decay resistance. The comparison for yellow poplar is complicated by high variability (standard error = 1.2), due to multiple decay failures at the 170°C treatment level among otherwise generally moderate visible decay.

Balsam fir L-joints treated at 170°C and 180°C had equivalent resistance to decay (Figure 1, Tables B1-B5). They were also generally equivalent to the ACQ-C and WoodTreat Millwork

F. Thermal Modification (170°C) + DOT: There was an apparent synergy between the DOT and thermal (170°C) treatments. Thermal modification (170°C) + DOT treatment had equivalent decay resistance to thermal treatment at 180°C for both yellow poplar and red maple during this L-joint test exposure.

G. Insect Attack: There was variable, non-termite, insect attack among the L-joints.

This was the last agreed upon evaluation for project E48057C. Continued evaluations or follow-up tests should be considered, particularly since this test was, in many regards, inconclusive. The data in this and other related field tests[5] at the WPG Kipuka Field Test Site shows potential for long-term durability of thermally modified wood treated at 180°C in exterior above ground applications corresponding to AWPA UC3.[6] This would include end uses such as coated millwork and siding (UC3A) or decking and fence pickets (UC3B). However, more testing is needed to confirm these applications as appropriate uses for the thermally modified wood.

We welcome your questions or comments. I may be reached by telephone at (906) 487-3316 or e-mail at gmlarkin@mtu.edu. Dr. Xinfeng Xie, WPG Group Leader, may be reached at (906) 487-2294 or xinfengx@mtu.edu.

Yours truly,

Glenn M. Larkin

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Wood Protection Group

Cc: File: E48057C

[5] Project E48057A, *Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E16)*; and Project E48057B, *Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E18).*

[6] AWPA Standard U1-20, *Use Category System: User Specifications for Treated Wood*, American Wood Protection Association (2020) Birmingham, AL USA.

Appendix A: Test Site Information and Project Exposure History

Table A1. Summary of WPG Kipuka Field Test Site Characteristics

Test Site	Location	Climate Station	Station Number	Mean Annual Precipitation		Mean Annual Temperature		Scheffer Index	Soil Type		Known Fungi*		Known Insects*	
Kipuka	Kea'au, HI (USA)	Hilo Int'l Airport	511492	3220 mm	127"	23°C	74°F	330	Silty Clay Loam	Hilo Series	*Alternaria* spp.	Mold / Soft Rot	*Xylocopa* spp.	Carpenter Bee
											Antrodia vaillantii	Brown Rot		
											Antrodia xantha	Brown Rot		
											Cladosporium spp.	Mold / Soft Rot		
											Coniophora spp.	Brown Rot		
											Curvularia spp.	Mold / Soft Rot		
											Dacrymyces spp.	Brown Rot		
											Epicoccum spp.	Mold / Soft Rot		
											Fusarium spp.	Mold / Soft Rot		
											Hyphoderma spp.	White Rot		
											Neolentinus lepideus	Brown Rot		
											Paecilomyces spp.	Mold / Soft Rot		
											Penicillium spp.	Mold / Soft Rot		
											Perenniporia tephropora	White Rot		
											Phanaerochaete spp.	White Rot		
											Pleurotus ostreatus	White Rot		
											Pycnoporus cinnabarinus	White Rot		
											Sistotrema spp.	Brown Rot		
											Trichoderma spp.	Mold / Soft Rot		

*Isolated or observed by WPG

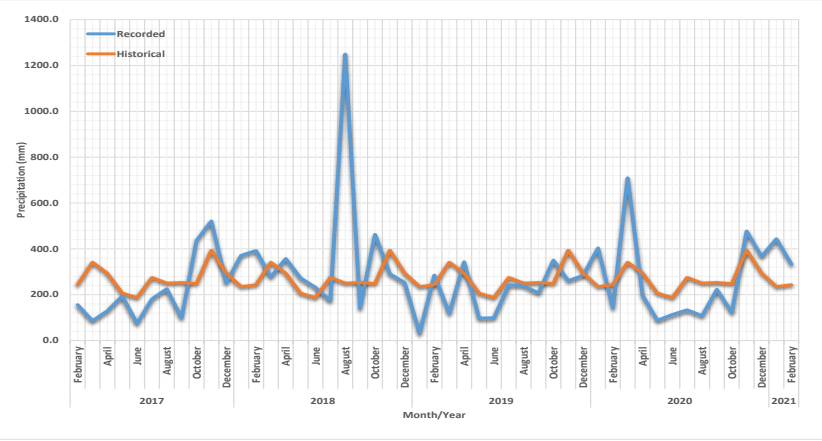

Figure A1. Measured (blue) and mean historical (red) monthly precipitation at the WPG Kipuka Field Test Site (red) during the field exposure.

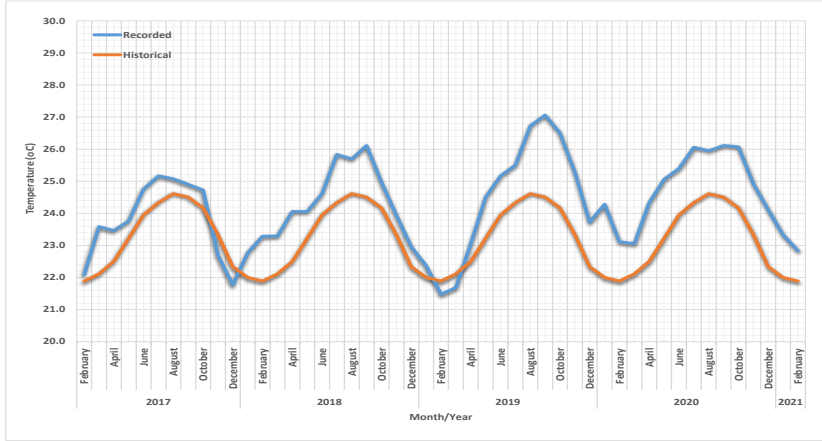

Figure A2. Measured mean (blue) and mean historical (red) monthly temperature at the WPG Kipuka Field Test Site (red) during the field exposure.

Table A2. Exposure and Inspection History of Specimens Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI

Test Site	Project#	Project Name	Test Method	WPG SOP	Specimen Type	Installation/Renewal Date	Inspection Date
Kipuka	E48057C	Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (AWPA E9)	AWPA E9	535	L-Joints	February 2017	
	48						Feb' 2021
	36						Feb' 2020
	24						Feb' 2019
	12						Feb' 2018

Appendix B: Above Ground Decay Test Data

Table B1. Mean Combined Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C)[a]

	Type	1	2	3	4	5	6	7	8	9	10	11	12	13
	Species	Yellow Poplar					Red Maple					White Ash		
L-Joints	Thermal Modification (°C)	180	170	170	N/A	N/A	180	170	170	N/A	N/A	180	170	N/A
	Preservative System	N/A		DOT[b]	DOT	N/A			DOT	DOT	N/A			
	Target Retention (kg/m^3)			4.5	4.5				4.5	4.5				
February	Exposure (Months)	Mean Combined Decay Rating												
2017	0	Installed												
2018	12	9.7	9.6	10	9.8	8.5	10	9.6	10	9.8	8.1	10	10	9.3
2019	24	9.1	8.9	9.8	8.1	2.6	9.9	8.3	9.5	8.4	4.2	10	9.7	8.5
2020	36	8.4	6.6	8.5	4.8	0.4	8.8	6.1	8.3	3.9	1.4	9.4	8.0	6.8
2021	48	8.0	5.4	7.9	2.5	0.6	8.2	4.7	7.9	0.6	0.0	9.2	7.6	6.4
February	Exposure (Months)	Mean Combined Insect Rating												
2017	0	Installed												
2018	12	10	10	10	10	10	10	10	10	10	9.7	10	10	10
2019	24	9.9	9.8	9.9	9.5	7.9	10	9.8	9.9	9.9	8.5	10	10	9.8
2020	36	9.9	9.5	9.9	7.5	7.5	10	9.4	9.6	8.3	7.7	10	9.7	9.5
2021	48	9.6	9.1	9.3	6.8	8.0	10	8.0	9.2	7.4	6.3	10	8.8	8.7

Table B1. Mean Combined Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

	Type	14	15	16	17	18	19	20	21	22	23	24
	Species	Balsam Fir			Ponderosa Pine	Southern Pine				Aspen		
L-Joints	Thermal Modification (°C)	180	170	N/A						180	170	N/A
	Preservative System	N/A			WoodTreat Millwork[c]	ACQ-C[d]			N/A			
	Target Retention (kg/m^3)				0.21	1.0	2.0	4.0				
February	Exposure (Months)	Mean Combined Decay Rating										
2017	0	Installed										
2018	12	10	10	9.5	10	10	10	10	9.9	9.7	9.7	8.3
2019	24	9.9	9.6	8.3	10	10	10	10	8.4	9.8	7.8	3.4
2020	36	9.1	8.1	6.1	8.6	8.8	9.9	10	6.3	8.2	5.1	1.0
2021	48	8.5	7.7	5.7	7.0	8.0	8.9	10	4.0	7.8	3.9	0.0
February	Exposure (Months)	Mean Combined Insect Rating										
2017	0	Installed										
2018	12	10	10	10	10	10	10	10	10	10	10	10
2019	24	10	10	9.9	10	10	10	10	9.4	10	9.8	8.7
2020	36	10	9.5	9.7	10	9.7	10	10	8.7	9.9	9.1	8.0
2021	48	10	9.0	9.5	9.2	9.7	9.9	10	7.3	10	8.5	3.5

[a] Values shown are the lower of the mean decay or insect ratings for the mortise and tenon, which were evaluated separately.

[b] DOT = disodium octaborate tetrahydrate

[c] Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA)

[d] ACQ-C = Ammoniacal Copper Quat Type C

Table B2. Mean Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C)

Mortises	Type	1	2	3	4	5	6	7	8	9	10	11	12	13
	Species	Yellow Poplar					Red Maple					White Ash		
	Thermal Modification (°C)	180	170	170	N/A	N/A	180	170	170	N/A	N/A	180	170	N/A
	Preservative System	N/A		DOT[a]	DOT	N/A			DOT	DOT	N/A			
	Target Retention (kg/m^3)			4.5	4.5				4.5	4.5				
February	Exposure (Months)	Mean Mortise Decay Rating												
2017	0	Installed												
2018	12	9.7	9.7	10	9.8	8.7	10	9.6	10	9.9	8.1	10	10	9.3
2019	24	9.6	8.9	9.8	8.1	2.6	9.9	8.3	9.5	8.4	4.2	10	9.7	8.5
2020	36	8.6	6.7	8.5	5.0	0.4	9.0	6.9	8.4	4.4	2.6	9.6	8.0	7.7
2021	48	8.0	5.4	7.9	2.6	0.6	8.2	6.1	7.9	1.1	0.0	9.2	7.6	6.8
February	Exposure (Months)	Mean Mortise Insect Rating												
2017	0	Installed												
2018	12	10	10	10	10	10	10	10	10	10	9.7	10	10	10
2019	24	10	9.9	9.9	9.5	7.9	10	9.9	9.9	9.9	8.9	10	10	9.8
2020	36	9.9	9.5	9.9	7.5	7.8	10	9.4	9.7	8.4	8.1	10	9.9	9.5
2021	48	9.6	9.2	9.3	6.8	9.0	10	8.4	9.2	7.4	7.0	10	9.4	8.7

Table B2. Mean Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Mortises	Type	14	15	16	17	18	19	20	21	22	23	24
	Species	Balsam Fir			Ponderosa Pine	Southern Pine				Aspen		
	Thermal Modification (°C)	180	170	N/A						180	170	N/A
	Preservative System	N/A			WoodTreat Millwork[b]	ACQ-C[c]			N/A			
	Target Retention (kg/m^3)				0.21	1.0	2.0	4.0				
February	Exposure (Months)	Mean Mortise Decay Rating										
2017	0	Installed										
2018	12	10	10	9.5	10	10	10	10	9.9	9.7	9.7	8.3
2019	24	9.9	9.6	8.3	10	10	10	10	8.4	9.8	7.8	3.4
2020	36	9.3	8.1	6.7	8.6	9.0	9.9	10	6.4	8.5	5.4	1.6
2021	48	8.6	7.7	6.4	7.0	8.2	8.9	10	5.7	8.0	4.1	0.0
February	Exposure (Months)	Mean Mortise Insect Rating										
2017	0	Installed										
2018	12	10	10	10	10	10	10	10	10	10	10	10
2019	24	10	10	9.9	10	10	10	10	9.5	10	9.8	8.7
2020	36	10	9.5	9.7	10	9.8	10	10	9.2	9.9	9.6	8.0
2021	48	10	9.0	9.5	9.2	9.7	10	10	7.8	10	8.5	3.5

[a] DOT = disodium octaborate tetrahydrate

[b] Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA)

[c] ACQ-C = Ammoniacal Copper Quat Type C

Table B3. Mean Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C)

Tenons	Type	1	2	3	4	5	6	7	8	9	10	11	12	13
	Species	Yellow Poplar					Red Maple					White Ash		
	Thermal Modification (°C)	180	170	170	N/A	N/A	180	170	170	N/A	N/A	180	170	N/A
	Preservative System	N/A		DOT[a]	DOT	N/A			DOT	DOT	N/A			
	Target Retention (kg/m^3)			4.5	4.5				4.5	4.5				
February	Exposure (Months)	Mean Tenon Decay Rating												
2017	0	Installed												
2018	12	9.7	9.6	10	9.8	8.5	10	9.6	10	9.8	8.2	10	10	9.4
2019	24	9.1	8.9	9.9	8.2	2.6	10	8.3	9.6	8.4	4.3	10	9.8	8.6
2020	36	8.4	6.6	8.6	4.8	0.4	8.8	6.1	8.3	3.9	1.4	9.4	8.0	6.8
2021	48	8.2	5.5	8.0	2.5	0.6	8.5	4.7	8.1	0.6	0.0	9.2	7.6	6.4
February	Exposure (Months)	Mean Tenon Insect Rating												
2017	0	Installed												
2018	12	10	10	10	10	10	10	10	10	10	10	10	10	10
2019	24	9.9	9.8	9.9	9.5	8.2	10	9.8	9.9	10	8.5	10	10	10
2020	36	9.9	9.5	10	7.9	7.5	10	9.5	9.6	8.3	7.7	10	9.7	9.7
2021	48	9.8	9.1	10	7.0	8.0	9.9	8.0	9.2	7.7	6.3	10	8.8	8.8

Table B3. Mean Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Tenons	Type	14	15	16	17	18	19	20	21	22	23	24
	Species	Balsam Fir			Ponderosa Pine	Southern Pine				Aspen		
	Thermal Modification (°C)	180	170	N/A						180	170	N/A
	Preservative System	N/A			WoodTreat Millwork[b]	ACQ-C[c]			N/A			
	Target Retention (kg/m^3)				0.21	1.0	2.0	4.0				
February	Exposure (Months)	Mean Tenon Decay Rating										
2017	0	Installed										
2018	12	10	10	9.5	10	10	10	10	9.9	9.8	9.8	8.5
2019	24	10	9.8	8.5	10	10	10	10	8.5	9.9	8.1	3.4
2020	36	9.1	8.2	6.1	9.1	8.8	10	10	6.3	8.2	5.1	1.0
2021	48	8.5	7.8	5.7	7.9	8.0	8.9	10	4.0	7.8	3.9	0.0
February	Exposure (Months)	Mean Tenon Insect Rating										
2017	0	Installed										
2018	12	10	10	10	10	10	10	10	10	10	10	10
2019	24	10	10	9.9	10	10	10	10	9.4	10	9.8	8.9
2020	36	10	10	9.7	10	9.7	10	10	8.7	10	9.1	8.6
2021	48	9.7	10	9.8	9.7	9.7	9.9	10	7.3	10	8.9	3.5

[a] DOT = disodium octaborate tetrahydrate

[b] Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA)

[c] ACQ-C = Ammoniacal Copper Quat Type C

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C)

Type	Species	Yellow Poplar		Thermal Modification (°C)			180	Preservative System		N/A		Target Retention (kg/m³)			N/A	
1	"P" Series	6561	6562	6563	6564	6565	6566	6567	6568	6569	6570	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI[a]	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	10	10	9	10	9	10	9.7	0.5	0.2	9.4	10
2019	24	10	10	8	10	10	10	9	10	9	10	9.6	0.7	0.2	9.2	10
2020	36	9	8	7	9	9	8	9	9	8	10	8.6	0.8	0.3	8.1	9.1
2021	48	8	8	7	9	8	7	8	9	7	9	8.0	0.8	0.3	7.5	8.5
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	9	10	10	10	9.9	0.3	0.1	9.7	10
2021	48	10	9	9	10	10	10	9	10	9	10	9.6	0.5	0.2	9.3	10

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			170	Preservative System		N/A		Target Retention (kg/m³)			N/A	
2	"P" Series	6571	6572	6573	6574	6575	6576	6577	6578	6579	6580	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	10	9	9	10	10	10	10	10	10	9.7	0.5	0.2	9.4	10
2019	24	8	8	10	9	9	9	9	9	10	8	8.9	0.7	0.2	8.4	9.4
2020	36	6	7	0	8	8	8	7	7	8	8	6.7	2.5	0.8	5.2	8.2
2021	48	0	0	0	7	8	8	8	8	8	7	5.4	3.7	1.2	3.1	7.7
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	9	10	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	7	10	9	10	10	10	10	9	10	10	9.5	1.0	0.3	8.9	10
2021	48	8	9	DF	9	10	10	10	10	9	8	9.2	0.8	0.3	8.7	10

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			170	Preservative System		DOT[b]		Target Retention (kg/m³)			4.5	
3	"P" Series	6581	6582	6583	6584	6585	6586	6587	6588	6589	6590	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	9	9	10	10	10	10	10	9.8	0.4	0.1	9.5	10
2020	36	9	9	9	8	8	8	8	8	9	9	8.5	0.5	0.2	8.2	8.8
2021	48	7	8	8	8	9	7	8	8	8	8	7.9	0.6	0.2	7.5	8.3
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	9	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	10	10	10	10	10	10	9	10	10	10	9.9	0.3	0.1	9.7	10
2021	48	8	9	10	10	10	9	8	9	10	10	9.3	0.8	0.3	8.8	9.8

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			N/A	Preservative System		DOT		Target Retention (kg/m³)				4.5
4	"P" Series	6591	6592	6593	6594	6595	6596	6597	6598	6599	6600	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	9	10	10	10	10	9	9.8	0.4	0.1	9.5	10
2019	24	9	10	7	8	8	8	10	8	7	6	8.1	1.3	0.4	7.3	8.9
2020	36	6	6	4	4	0	7	7	6	4	6	5.0	2.1	0.7	3.7	6.3
2021	48	0	6	M	0	0	6	7	0	0	4	2.6	3.1	1.0	0.5	4.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	8	10	9	10	10	10	10	8	9.5	0.8	0.3	9.0	10
2020	36	6	7	6	10	7	8	9	8	7	7	7.5	1.3	0.4	6.7	8.3
2021	48	6	6	M	8	DF	7	8	7	6	6	6.8	0.9	0.3	6.1	7.4

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)				N/A
5	"P" Series	6601	6602	6603	6604	6605	6606	6607	6608	6609	6610	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	10	9	7	8	9	9	9	8	9	8.7	0.8	0.3	8.2	9.2
2019	24	0	6	0	0	0	6	0	7	0	7	2.6	3.4	1.1	0.5	4.7
2020	36	0	0	0	0	0	0	0	4	0	0	0.4	1.3	0.4	0.0	1.2
2021	48	0	0	0	0	0	0	0	6	0	0	0.6	1.9	0.6	0.0	1.8
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	7	9	8	8	8	10	6	9	4	10	7.9	1.9	0.6	6.8	9.0
2020	36	DF	7	DF	DF	DF	8	DF	9	DF	7	7.8	1.0	0.5	6.8	8.7
2021	48	DF	DF	DF	DF	DF	DF	DF	9	DF	DF	9.0	0.0	0.0	9.0	9.0

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			180	Preservative System		N/A		Target Retention (kg/m³)				N/A
6	"P" Series	6611	6612	6613	6614	6615	6616	6617	6618	6619	6620	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	9	10	9.9	0.3	0.1	9.7	10
2020	36	8	8	10	9	9	10	10	9	8	9	9.0	0.8	0.3	8.5	9.5
2021	48	8	8	8	9	9	8	9	8	7	8	8.2	0.6	0.2	7.8	8.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	9	10	9	10	10	10	10	9.8	0.4	0.1	9.5	10

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			170	Preservative System		N/A		Target Retention (kg/m³)			N/A	
7	"P" Series	6621	6622	6623	6624	6625	6626	6627	6628	6629	6630	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	8	10	10	9	10	10	9	10	10	10	9.6	0.7	0.2	9.2	10
2019	24	8	9	8	6	8	9	9	8	9	9	8.3	0.9	0.3	7.7	8.9
2020	36	7	4	8	4	8	7	8	9	7	7	6.9	1.7	0.5	5.9	7.9
2021	48	7	6	6	M	7	0	7	7	8	7	6.1	2.4	0.8	4.6	7.7
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	9	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	9	9	9	9	10	9	10	10	10	9	9.4	0.5	0.2	9.1	9.7
2021	48	9	7	8	M	8	8	8	10	10	8	8.4	1.0	0.3	7.8	9.1

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			170	Preservative System		DOT		Target Retention (kg/m³)			4.5	
8	"P" Series	6631	6632	6633	6634	6635	6636	6637	6638	6639	6640	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	9	10	9	9	10	10	10	9	9	9.5	0.5	0.2	9.2	9.8
2020	36	8	7	9	8	8	10	9	9	9	7	8.4	1.0	0.3	7.8	9.0
2021	48	8	8	8	9	7	9	8	9	7	6	7.9	1.0	0.3	7.3	8.5
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	9	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	10	10	10	9	9	10	10	10	10	9	9.7	0.5	0.2	9.4	10
2021	48	10	9	9	9	8	10	10	10	9	8	9.2	0.8	0.2	8.7	9.7

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			N/A	Preservative System		DOT		Target Retention (kg/m³)			4.5	
9	"P" Series	6641	6642	6643	6644	6645	6646	6647	6648	6649	6650	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	9	10	10	9.9	0.3	0.1	9.7	10
2019	24	8	8	9	9	9	9	9	6	9	8	8.4	1.0	0.3	7.8	9.0
2020	36	6	6	4	4	6	0	6	0	6	6	4.4	2.5	0.8	2.9	5.9
2021	48	6	4	M	0	0	0	0	0	0	0	1.1	2.3	0.8	0.0	2.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	9	10	9.9	0.3	0.1	9.7	10
2020	36	8	10	8	8	8	7	10	8	8	9	8.4	1.0	0.3	7.8	9.0
2021	48	7	8	M	6	8	DF	8	DF	7	8	7.4	0.8	0.3	6.8	8.0

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m³)			N/A	
10	"P" Series	6651	6652	6653	6654	6655	6656	6657	6658	6659	6660	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	7	8	8	7	8	9	8	9	9	8	8.1	0.7	0.2	7.6	8.6
2019	24	0	6	7	0	7	7	7	0	4	4	4.2	3.1	1.0	2.3	6.1
2020	36	0	6	4	0	6	6	0	0	4	0	2.6	2.8	0.9	0.8	4.4
2021	48	0	0	M	0	0	0	0	0	M	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	9	10	10	10	10	10	9	9.7	0.5	0.2	9.4	10
2019	24	8	9	9	10	10	10	10	8	7	8	8.9	1.1	0.3	8.2	9.6
2020	36	DF	8	8	DF	10	8	9	DF	7	7	8.1	1.1	0.4	7.4	8.9
2021	48	DF	7	M	DF	8	6	DF	DF	M	DF	7.0	1.0	0.6	5.9	8.1

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m³)			N/A	
11	"P" Series	6661	6662	6663	6664	6665	6666	6667	6668	6669	6670	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	9	9	10	9	10	10	10	10	9	10	9.6	0.5	0.2	9.3	9.9
2021	48	9	9	8	9	9	10	10	9	9	10	9.2	0.6	0.2	8.8	9.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m³)			N/A	
12	"P" Series	6671	6672	6673	6674	6675	6676	6677	6678	6679	6680	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	9	10	9	10	10	9	10	9.7	0.5	0.2	9.4	10
2020	36	7	7	9	8	10	7	9	7	7	9	8.0	1.2	0.4	7.3	8.7
2021	48	6	8	9	8	8	6	8	7	8	8	7.6	1.0	0.3	7.0	8.2
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	9	10	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2021	48	8	9	10	10	10	10	8	10	10	9	9.4	0.8	0.3	8.9	9.9

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m³)			N/A	
13	"P" Series	6681	6682	6683	6684	6685	6686	6687	6688	6689	6690	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	8	9	8	10	10	8	10	9.3	0.9	0.3	8.7	9.9
2019	24	9	10	9	8	9	8	9	7	8	8	8.5	0.8	0.3	8.0	9.0
2020	36	9	10	8	6	8	7	9	7	7	6	7.7	1.3	0.4	6.9	8.5
2021	48	8	9	9	6	7	7	8	M	7	0	6.8	2.7	0.9	5.0	8.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	9	10	9	10	10	10	10	9.8	0.4	0.1	9.5	10
2020	36	10	10	10	7	9	10	10	10	10	9	9.5	1.0	0.3	8.9	10
2021	48	10	10	10	7	8	8	10	M	8	7	8.7	1.3	0.4	7.8	9.5

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m³)			N/A	
14	"P" Series	6691	6692	6693	6694	6695	6696	6697	6698	6699	6700	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	9	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	10	9	9	10	9	10	9	8	9	10	9.3	0.7	0.2	8.9	9.7
2021	48	10	7	9	9	9	10	7	7	9	9	8.6	1.2	0.4	7.9	9.3
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	8	10	10	10	10	9	10	10	10	9.7	0.7	0.2	9.3	10

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m³)			N/A	
15	"P" Series	6701	6702	6703	6704	6705	6706	6707	6708	6709	6710	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	9	8	9	10	10	10	10	10	9.6	0.7	0.2	9.2	10
2020	36	9	9	7	7	8	9	8	9	8	7	8.1	0.9	0.3	7.6	8.6
2021	48	7	8	8	7	7	9	8	8	8	7	7.7	0.7	0.2	7.3	8.1
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	9	8	9	9	10	10	10	10	10	9.5	0.7	0.2	9.1	9.9
2021	48	9	9	9	9	8	10	9	9	9	9	9.0	0.5	0.1	8.7	9.3

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)			N/A	
16	"P" Series	6711	6712	6713	6714	6715	6716	6717	6718	6719	6720	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	9	9	10	10	10	8	9.5	0.7	0.2	9.1	9.9
2019	24	9	9	9	10	9	8	10	10	9	0	8.3	3.0	0.9	6.5	10
2020	36	8	7	6	7	7	8	10	10	4	0	6.7	2.9	0.9	4.9	8.5
2021	48	8	6	7	6	7	8	8	8	M	0	6.4	2.6	0.9	4.8	8.1
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	9	9.9	0.3	0.1	9.7	10
2020	36	10	9	10	10	10	10	10	10	8	DF	9.7	0.7	0.2	9.2	10
2021	48	10	7	10	10	10	10	9	10	M	DF	9.5	1.1	0.4	8.8	10

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Ponderosa Pine		Thermal Modification (°C)			N/A	Preservative System		WoodTreat Millwork[c]		Target Retention (kg/m³)			0.21	
17	"P" Series	6721	6722	6723	6724	6725	6726	6727	6728	6729	6730	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	8	6	9	8	10	9	9	9	8	8.6	1.2	0.4	7.9	9.3
2021	48	7	8	6	9	7	9	8	0	9	7	7.0	2.7	0.8	5.3	8.7
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	9	10	10	10	10	10	10	10	10	10	0.3	0.1	9.7	10
2021	48	8	7	10	10	10	10	9	8	10	10	9.2	1.1	0.4	8.5	9.9

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C[b]		Target Retention (kg/m³)			4.0	
20	"P" Series	6731	6732	6733	6734	6735	6736	6737	6738	6739	6740	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	M	10	10	10	10	10	9	9	10	9.8	0.4	0.1	9.5	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	M	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C		Target Retention (kg/m³)				2.0
19	"P" Series	6741	6742	6743	6744	6745	6746	6747	6748	6749	6750	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	9	10	10	9.9	0.3	0.1	9.7	10
2021	48	10	10	10	0	10	10	10	9	10	10	8.9	3.1	1.0	7.0	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C		Target Retention (kg/m³)				1.0
18	"P" Series	6751	6752	6753	6754	6755	6756	6757	6758	6759	6760	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	4	10	M	M	M	M	10	9.0	2.4	1.0	7.0	10
2021	48	10	9	10	0	10	M	M	M	M	10	8.2	4.0	1.6	4.9	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	9	10	M	M	M	M	10	9.8	0.4	0.2	9.5	10
2021	48	10	10	10	8	10	M	M	M	M	10	9.7	0.8	0.3	9.0	10

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)				N/A
21	"P" Series	6761	6762	6763	6764	6765	6766	6767	6768	6769	6770	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2019	24	8	9	10	10	10	0	10	9	9	9	8.4	3.0	1.0	6.5	10
2020	36	7	0	8	8	8	0	9	7	8	9	6.4	3.4	1.1	4.3	8.5
2021	48	7	0	8	7	7	0	9	6	6	7	5.7	3.1	1.0	3.8	7.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	9	10	10	10	6	10	10	10	10	9.5	1.3	0.4	8.7	10
2020	36	8	7	10	10	9	DF	10	9	10	10	9.2	1.1	0.4	8.5	9.9
2021	48	7	DF	9	7	7	DF	10	6	7	9	7.8	1.4	0.5	6.8	8.7

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			180	Preservative System		N/A		Target Retention (kg/m³)				N/A
22	"P" Series	6771	6772	6773	6774	6775	6776	6777	6778	6779	6780	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	10	10	10	10	9	9	10	10	10	9.7	0.5	0.2	9.4	10
2019	24	9	10	10	10	10	10	9	10	10	10	9.8	0.4	0.1	9.5	10
2020	36	9	8	8	8	9	8	8	9	9	9	8.5	0.5	0.2	8.2	8.8
2021	48	8	9	8	8	7	7	8	9	7	9	8.0	0.8	0.3	7.5	8.5
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	9	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2021	48	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			170	Preservative System		N/A		Target Retention (kg/m³)				N/A
23	"P" Series	6781	6782	6783	6784	6785	6786	6787	6788	6789	6790	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	9	10	10	9	10	10	9	10	9.7	0.5	0.2	9.4	10
2019	24	9	8	7	10	9	8	9	9	0	9	7.8	2.9	0.9	6.0	9.6
2020	36	6	7	0	7	7	6	8	6	0	7	5.4	2.9	0.9	3.6	7.2
2021	48	0	0	0	6	8	6	8	6	0	7	4.1	3.6	1.1	1.9	6.3
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	8	10	9.8	0.6	0.2	9.4	10
2020	36	10	10	9	9	10	8	10	10	DF	10	9.6	0.7	0.2	9.1	10
2021	48	7	10	DF	8	10	8	8	8	DF	9	8.5	1.1	0.4	7.8	9.2

Table B4. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)				N/A
24	"P" Series	6791	6792	6793	6794	6795	6796	6797	6798	6799	6800	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	8	7	10	7	9	8	9	8	8	8.3	0.9	0.3	7.7	8.9
2019	24	0	0	0	9	4	7	7	7	0	0	3.4	3.8	1.2	1.1	5.7
2020	36	0	0	0	6	0	6	0	4	0	0	1.6	2.6	0.8	0.0	3.2
2021	48	0	0	0	M	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	8	8	9	10	6	10	10	10	8	8	8.7	1.3	0.4	7.9	9.5
2020	36	DF	DF	DF	10	6	9	8	7	DF	DF	8.0	1.6	0.7	6.6	9.4
2021	48	DF	DF	DF	M	DF	7	DF	0	DF	DF	3.5	4.9	3.5	0.0	10

[a] Lower CI = Lowe 95% Confidence Interval, Upper CI = Upper 95% Confidence Interval

[b] DOT = disodium octaborate tetrahydrate, ACQ-C = Ammoniacal Copper Quat Type C

[c] Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA)

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C)

Type	Species	Yellow Poplar		Thermal Modification (°C)			180	Preservative System		N/A		Target Retention (kg/m³)			N/A	
1	"P" Series	6561	6562	6563	6564	6565	6566	6567	6568	6569	6570	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI[a]	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	10	10	9	10	9	10	9.7	0.5	0.2	9.4	10
2019	24	6	9	8	10	10	10	8	10	10	10	9.1	1.4	0.4	8.3	9.9
2020	36	9	8	7	9	9	8	8	8	8	10	8.4	0.8	0.3	7.9	8.9
2021	48	9	8	7	9	8	7	8	9	8	9	8.2	0.8	0.2	7.7	8.7
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	9	10	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	10	10	10	10	10	10	9	10	10	10	9.9	0.3	0.1	9.7	10
2021	48	10	10	10	10	9	10	9	10	10	10	9.8	0.4	0.1	9.5	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			170	Preservative System		N/A		Target Retention (kg/m³)			N/A	
2	"P" Series	6571	6572	6573	6574	6575	6576	6577	6578	6579	6580	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	10	9	9	9	10	10	10	10	10	9.6	0.5	0.2	9.3	10
2019	24	8	8	10	10	8	9	9	9	10	8	8.9	0.9	0.3	8.4	9.4
2020	36	7	6	0	8	8	7	7	7	8	8	6.6	2.4	0.8	5.1	8.1
2021	48	0	0	0	7	8	8	8	8	8	8	5.5	3.8	1.2	3.1	7.9
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	9	9	10	10	10	10	10	10	10	10	9.8	0.4	0.1	9.5	10
2020	36	7	10	9	10	10	10	10	9	10	10	9.5	1.0	0.3	8.9	10
2021	48	7	10	DF	10	9	9	10	8	10	9	9.1	1.1	0.4	8.4	9.8

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			170	Preservative System		DOT[b]		Target Retention (kg/m³)			4.5	
3	"P" Series	6581	6582	6583	6584	6585	6586	6587	6588	6589	6590	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	9	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	9	9	9	8	8	9	8	8	9	9	8.6	0.5	0.2	8.3	8.9
2021	48	7	8	8	8	8	8	8	9	8	8	8.0	0.5	0.1	7.7	8.3
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	9	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	9	10	10	10	10	10	9	9	10	10	9.7	0.5	0.2	9.4	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			N/A	Preservative System		DOT		Target Retention (kg/m^3)			4.5	
4	"P" Series	6591	6592	6593	6594	6595	6596	6597	6598	6599	6600	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	9	10	10	10	10	9	9.8	0.4	0.1	9.5	10
2019	24	9	9	6	8	8	9	10	9	8	6	8.2	1.3	0.4	7.4	9.0
2020	36	6	7	0	4	0	7	8	6	4	6	4.8	2.8	0.9	3.1	6.5
2021	48	0	6	0	0	0	6	7	0	0	6	2.5	3.2	1.0	0.5	4.5
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	8	10	9	10	10	10	10	8	9.5	0.8	0.3	9.0	10
2020	36	8	8	7	10	7	8	9	9	6	7	7.9	1.2	0.4	7.2	8.6
2021	48	7	7	DF	8	DF	7	9	6	6	6	7.0	1.1	0.4	6.3	7.7

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Yellow Poplar		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m^3)			N/A	
5	"P" Series	6601	6602	6603	6604	6605	6606	6607	6608	6609	6610	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	9	8	8	8	8	9	9	8	9	8.5	0.5	0.2	8.2	8.8
2019	24	0	6	0	0	0	6	0	7	0	7	2.6	3.4	1.1	0.5	4.7
2020	36	0	0	0	0	0	0	0	4	0	0	0.4	1.3	0.4	0.0	1.2
2021	48	0	0	0	0	0	0	0	6	0	0	0.6	1.9	0.6	0.0	1.8
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	7	9	8	8	8	9	8	9	6	10	8.2	1.1	0.4	7.5	8.9
2020	36	DF	7	DF	DF	DF	8	DF	8	DF	7	7.5	0.6	0.3	6.9	8.1
2021	48	DF	DF	DF	DF	DF	DF	DF	8	DF	DF	8.0	0.0	0.0	8.0	8.0

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C)

Type	Species	Red Maple		Thermal Modification (°C)			180	Preservative System		N/A		Target Retention (kg/m^3)			N/A	
6	"P" Series	6611	6612	6613	6614	6615	6616	6617	6618	6619	6620	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	8	8	10	9	8	10	9	9	9	8	8.8	0.8	0.2	8.3	9.3
2021	48	9	9	9	9	8	8	9	8	8	8	8.5	0.5	0.2	8.2	8.8
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	9	10	10	10	10	10	9.9	0.3	0.1	9.7	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)		170		Preservative System		N/A		Target Retention (kg/m³)			N/A	
7	"P" Series	6621	6622	6623	6624	6625	6626	6627	6628	6629	6630	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	8	10	10	10	10	10	9	9	10	10	9.6	0.7	0.2	9.2	10
2019	24	8	9	8	6	8	9	9	8	9	9	8.3	0.9	0.3	7.7	8.9
2020	36	7	4	7	0	8	7	7	8	7	6	6.1	2.4	0.8	4.6	7.6
2021	48	7	0	6	0	7	0	7	7	7	6	4.7	3.3	1.0	2.7	6.7
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	9	9	10	10	10	10	10	10	9.8	0.4	0.1	9.5	10
2020	36	10	9	10	9	10	9	10	10	10	8	9.5	0.7	0.2	9.1	9.9
2021	48	8	7	8	DF	9	8	8	8	8	8	8.0	0.5	0.2	7.7	8.3

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)		170		Preservative System		DOT		Target Retention (kg/m³)			4.5	
8	"P" Series	6631	6632	6633	6634	6635	6636	6637	6638	6639	6640	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	9	9	10	10	10	10	8	9.6	0.7	0.2	9.2	10
2020	36	8	7	9	8	8	10	9	9	9	6	8.3	1.2	0.4	7.6	9.0
2021	48	8	8	9	8	8	9	8	10	7	6	8.1	1.1	0.3	7.4	8.8
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	9	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	10	10	9	9	9	10	10	10	10	9	9.6	0.5	0.2	9.3	10
2021	48	10	10	9	9	8	9	10	10	9	8	9.2	0.8	0.2	8.7	9.7

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)		N/A		Preservative System		DOT		Target Retention (kg/m³)			4.5	
9	"P" Series	6641	6642	6643	6644	6645	6646	6647	6648	6649	6650	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	10	10	10	9	10	10	9.8	0.4	0.1	9.5	10
2019	24	8	8	9	9	9	9	9	6	9	8	8.4	1.0	0.3	7.8	9.0
2020	36	6	4	0	6	6	0	7	0	6	4	3.9	2.8	0.9	2.1	5.7
2021	48	6	0	0	0	0	0	0	0	0	0	0.6	1.9	0.6	0.0	1.8
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	8	8	9	9	8	7	10	7	7	10	8.3	1.2	0.4	7.6	9.0
2021	48	8	7	DF	7	7	DF	10	DF	7	8	7.7	1.1	0.4	6.9	8.5

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Red Maple		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m^3)			N/A	
10	"P" Series	6651	6652	6653	6654	6655	6656	6657	6658	6659	6660	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	7	8	8	7	8	10	8	9	9	8	8.2	0.9	0.3	7.6	8.8
2019	24	0	6	7	0	7	6	7	0	6	4	4.3	3.1	1.0	2.4	6.2
2020	36	0	4	0	0	6	4	0	0	0	0	1.4	2.3	0.7	0.0	2.8
2021	48	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	8	9	9	8	10	9	9	7	8	8	8.5	0.8	0.3	8.0	9.0
2020	36	DF	8	7	DF	9	8	8	DF	7	7	7.7	0.8	0.3	7.2	8.3
2021	48	DF	6	DF	DF	7	6	DF	DF	DF	DF	6.3	0.6	0.3	5.7	7.0

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C)

Type	Species	White Ash		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m^3)			N/A	
11	"P" Series	6661	6662	6663	6664	6665	6666	6667	6668	6669	6670	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	9	9	9	10	9	10	9	10	9	10	9.4	0.5	0.2	9.1	9.7
2021	48	9	10	9	9	9	9	9	9	9	10	9.2	0.4	0.1	8.9	9.5
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m^3)			N/A	
12	"P" Series	6671	6672	6673	6674	6675	6676	6677	6678	6679	6680	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	9	10	9	10	10	10	10	9.8	0.4	0.1	9.5	10
2020	36	7	6	9	8	9	7	9	8	8	9	8.0	1.1	0.3	7.3	8.7
2021	48	6	7	9	8	9	6	8	7	8	8	7.6	1.1	0.3	6.9	8.3
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	9	10	9	10	10	10	10	10	9	10	9.7	0.5	0.2	9.4	10
2021	48	7	8	9	10	10	9	8	9	10	8	8.8	1.0	0.3	8.2	9.4

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	White Ash		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m^3)			N/A	
13	"P" Series	6681	6682	6683	6684	6685	6686	6687	6688	6689	6690	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	8	9	9	10	10	8	10	9.4	0.8	0.3	8.9	9.9
2019	24	9	10	10	8	9	8	9	7	8	8	8.6	1.0	0.3	8.0	9.2
2020	36	8	9	7	6	8	7	9	0	7	7	6.8	2.6	0.8	5.2	8.4
2021	48	9	9	9	6	7	8	9	0	7	0	6.4	3.5	1.1	4.2	8.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	8	10	10	10	10	9	10	9.7	0.7	0.2	9.3	10
2021	48	10	10	10	8	7	9	10	DF	8	7	8.8	1.3	0.4	7.9	9.6

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			180	Preservative System			N/A	Target Retention (kg/m^3)			N/A	
14	"P" Series	6691	6692	6693	6694	6695	6696	6697	6698	6699	6700	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	8	10	10	10	9	9	7	8	10	9.1	1.1	0.3	8.4	9.8
2021	48	9	7	9	9	9	10	8	7	8	9	8.5	1.0	0.3	7.9	9.1
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	9	10	10	9	10	10	10	10	9	9.7	0.5	0.2	9.4	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Balsam Fir		Thermal Modification (°C)			170	Preservative System			N/A	Target Retention (kg/m^3)			N/A	
15	"P" Series	6701	6702	6703	6704	6705	6706	6707	6708	6709	6710	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	9	9	10	10	10	10	10	10	9.8	0.4	0.1	9.5	10
2020	36	9	9	7	7	8	9	8	9	9	7	8.2	0.9	0.3	7.6	8.8
2021	48	8	8	7	8	8	8	7	8	9	7	7.8	0.6	0.2	7.4	8.2
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	8	10	10	10	10	10	10	10	9.8	0.6	0.2	9.4	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C)

Type	Species	Balsam Fir		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m^3)			N/A	
16	"P" Series	6711	6712	6713	6714	6715	6716	6717	6718	6719	6720	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	9	9	10	10	10	8	9.5	0.7	0.2	9.1	9.9
2019	24	10	9	10	10	9	8	10	10	9	0	8.5	3.1	1.0	6.6	10
2020	36	8	7	7	7	7	7	9	9	0	0	6.1	3.3	1.0	4.0	8.2
2021	48	7	6	8	6	7	7	8	8	0	0	5.7	3.1	1.0	3.8	7.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	9	9.9	0.3	0.1	9.7	10
2020	36	10	10	10	9	10	10	10	10	8	DF	9.7	0.7	0.2	9.2	10
2021	48	10	8	10	10	10	10	10	10	DF	DF	9.8	0.7	0.3	9.3	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Ponderosa Pine		Thermal Modification (°C)			N/A	Preservative System		WoodTreat Millwork[c]		Target Retention (kg/m^3)			0.21	
17	"P" Series	6721	6722	6723	6724	6725	6726	6727	6728	6729	6730	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	9	7	9	9	10	10	9	9	9	9.1	0.9	0.3	8.6	9.6
2021	48	8	8	6	9	7	10	9	6	9	7	7.9	1.4	0.4	7.1	8.7
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	9	8	10	10	10	10	10	10	10	10	9.7	0.7	0.2	9.3	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C[b]		Target Retention (kg/m^3)			4.0	
20	"P" Series	6731	6732	6733	6734	6735	6736	6737	6738	6739	6740	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	M	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	M	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C		Target Retention (kg/m³)				2.0
19	"P" Series	6741	6742	6743	6744	6745	6746	6747	6748	6749	6750	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	0	10	10	10	9	10	10	8.9	3.1	1.0	7.0	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	10	10	10	9	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		ACQ-C		Target Retention (kg/m³)				1.0
18	"P" Series	6751	6752	6753	6754	6755	6756	6757	6758	6759	6760	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	9	10	4	10	M	M	M	M	10	8.8	2.4	1.0	6.9	10
2021	48	10	9	9	0	10	M	M	M	M	10	8.0	3.9	1.6	4.8	10
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	8	10	M	M	M	M	10	9.7	0.8	0.3	9.0	10
2021	48	10	10	10	8	10	M	M	M	M	10	9.7	0.8	0.3	9.0	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C)

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)				N/A
21	"P" Series	6761	6762	6763	6764	6765	6766	6767	6768	6769	6770	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	9	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2019	24	8	9	10	10	10	0	10	9	9	10	8.5	3.1	1.0	6.6	10
2020	36	6	4	8	4	8	0	9	7	8	9	6.3	2.9	0.9	4.5	8.1
2021	48	7	M	8	0	0	0	9	6	6	0	4.0	3.9	1.3	1.4	6.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	8	10	10	10	6	10	10	10	10	9.4	1.3	0.4	8.6	10
2020	36	8	7	10	7	8	DF	10	9	9	10	8.7	1.2	0.4	7.9	9.5
2021	48	7	M	9	0	7	DF	10	8	9	8	7.3	3.1	1.1	5.1	9.4

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			180	Preservative System		N/A		Target Retention (kg/m³)			N/A	
22	"P" Series	6771	6772	6773	6774	6775	6776	6777	6778	6779	6780	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	10	10	10	10	9	10	10	10	10	9.8	0.4	0.1	9.5	10
2019	24	9	10	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	36	8	9	8	8	8	8	8	9	8	8	8.2	0.4	0.1	7.9	8.5
2021	48	7	9	8	8	7	7	8	8	7	9	7.8	0.8	0.2	7.3	8.3
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	36	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	48	9	10	10	10	10	10	9	10	10	10	9.8	0.4	0.1	9.5	10

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			170	Preservative System		N/A		Target Retention (kg/m³)			N/A	
23	"P" Series	6781	6782	6783	6784	6785	6786	6787	6788	6789	6790	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	9	10	10	10	10	10	9	10	9.8	0.4	0.1	9.5	10
2019	24	8	10	8	10	9	9	9	9	0	9	8.1	2.9	0.9	6.3	9.9
2020	36	4	6	0	7	7	6	7	7	0	7	5.1	2.8	0.9	3.3	6.9
2021	48	0	0	0	4	7	6	8	8	0	6	3.9	3.5	1.1	1.7	6.1
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	10	10	10	10	10	10	10	10	8	10	9.8	0.6	0.2	9.4	10
2020	36	8	9	8	10	10	8	9	10	DF	10	9.1	0.9	0.3	8.5	9.7
2021	48	8	8	DF	9	10	8	9	10	DF	9	8.9	0.8	0.3	8.3	9.5

Table B5. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project 48057C) - *Continued*

Type	Species	Aspen		Thermal Modification (°C)			N/A	Preservative System		N/A		Target Retention (kg/m³)			N/A	
24	"P" Series	6791	6792	6793	6794	6795	6796	6797	6798	6799	6800	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	9	8	7	10	7	9	9	9	9	8	8.5	1.0	0.3	7.9	9.1
2019	24	0	0	0	9	4	7	8	6	0	0	3.4	3.8	1.2	1.0	5.8
2020	36	0	0	0	0	0	4	0	6	0	0	1.0	2.2	0.7	0.0	2.3
2021	48	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2017	0	Installed										10	0.0	0.0	10	10
2018	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2019	24	8	8	7	10	9	9	10	10	8	10	8.9	1.1	0.3	8.2	10
2020	36	DF	DF	DF	10	8	9	8	8	DF	DF	8.6	0.9	0.4	7.8	9.4
2021	48	DF	DF	DF	DF	DF	7	DF	0	DF	DF	3.5	4.9	3.5	0.0	10

[a] Lower CI = Lowe 95% Confidence Interval, Upper CI = Upper 95% Confidence Interval

[b] DOT = disodium octaborate tetrahydrate, ACQ-C = Ammoniacal Copper Quat Type C

[c] Woodtreat Millwork is a registered trademark of Kop-Coat (Pittsburgh, PA)

Michigan Technological University
College of Forest Resources and Environmental Science

Matt Aro
Natural Resources Research Institute
5013 Miller Trunk Highway
Duluth, MN 55811

April 14, 2021

Dear Matt,

This letter serves as the final report for Project WPG180122C, **Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (E9 – Add On).** The L- joints were evaluated on February 11, 2021 at the Michigan Tech Wood Protection Group (WPG) Kipuka Field Test Site near Hilo, HI. Kipuka site characteristics, climate data during the exposure period, and the test exposure history are included in Appendix A. Test data is attached as Appendix B.

L-Joints (36 Months, Evaluation 3 of 3 for Current Contract)

The Natural Resources Research Institute at the University of Minnesota at Duluth (NRRI) prepared L-joints for eastern hemlock (*Tsuga canadensis*) then modified them by thermal treatment at 170°C or 180°C. Southern (*Pinus* spp.) was prepared, without thermal treatment as a control. The L-joints were shipped to the WPG in Houghton, MI, where each was assembled and uniquely labelled using stainless steel ID tags and fasteners.

The field-ready L-joints were shipped to the test site near Hilo, HI, and installed in an AWPA E9[1] decay test during February 2018. Evaluations were performed and reported separately for the mortise and tenon. A combined rating, the lower value of the mortise or tenon, is also reported (Table B1, Appendix B). There was strong agreement between the L-Joint decay ratings for the mortises and tenons (r = 0.86), therefore the discussion is based on the combined ratings. At 36 months of field exposure:

A. Untreated Controls: There was severe visible decay among the untreated eastern hemlock and southern pine L-joints. Insect attack among these L-joints was moderate and secondary to decay, caused by non-termite species excavating previously deteriorated wood.

B. Thermal Modification: Test results seem to indicate that thermal modification at 180°C may improve the decay resistance of eastern hemlock in this test, compared to the controls. There was no apparent benefit among L-Joints that were thermally modified at 170°C. Insect attack among these L-joints was minor to moderate and also secondary to decay.

[1] Current Version: AWPA Standard E9-15 *Standard Field Test for Evaluation of Wood Preservatives to be Used Above Ground (UC3A & UC3B); L-Joint Test*, American Wood Protection Association (2020) Birmingham, AL USA.

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This was the last contracted evaluation for project WPG160122C. Continued evaluations may be warranted. More time is needed to establish the long-term decay resistance of thermally modified eastern hemlock using the AWPA E9 test format.

We welcome your questions or comments. I may be reached by telephone at (906) 487-3316 or e-mail at gmlarkin@mtu.edu. Dr. Xinfeng Xie, WPG Group Leader, may be reached at (906) 487-2294 or xinfengx@mtu.edu.

Yours truly,

Glenn M. Larkin

Glenn M. Larkin
Sr. Research Scientist
Wood Protection Group

Cc: File: WPG180122C

Appendix A: Test Site Information and Project Exposure History

Table A1. Summary of WPG Kipuka Field Test Site Characteristics

Test Site	Location	Climate Station	Station Number	Mean Annual Precipitation		Mean Annual Temperature		Scheffer Index	Soil Type		Known Fungi*		Known Insects*	
Kipuka	Kea'au, HI (USA)	Hilo Int'l Airport	511492	3220 mm	127"	23^{0}C	74^{0}F	330	Silty Clay Loam	Hilo Series	*Alternaria* spp.	Mold / Soft Rot	*Xylocopa* spp.	Carpenter Bee
											Antrodia vaillantii	Brown Rot		
											Antrodia xantha	Brown Rot		
											Cladosporium spp.	Mold / Soft Rot		
											Coniophora spp.	Brown Rot		
											Curvularia spp.	Mold / Soft Rot		
											Dacrymyces spp.	Brown Rot		
											Epicoccum spp.	Mold / Soft Rot		
											Fusarium spp.	Mold / Soft Rot		
											Hyphoderma spp.	White Rot		
											Neolentinus lepideus	Brown Rot		
											Paecilomyces spp.	Mold / Soft Rot		
											Penicillium spp.	Mold / Soft Rot		
											Perenniporia tephropora	White Rot		
											Phanaerochaete spp.	White Rot		
											Pleurotus ostreatus	White Rot		
											Pycnoporus cinnabarinus	White Rot		
											Sistotrema spp.	Brown Rot		
											Trichoderma spp.	Mold / Soft Rot		

*Isolated or observed by WPG

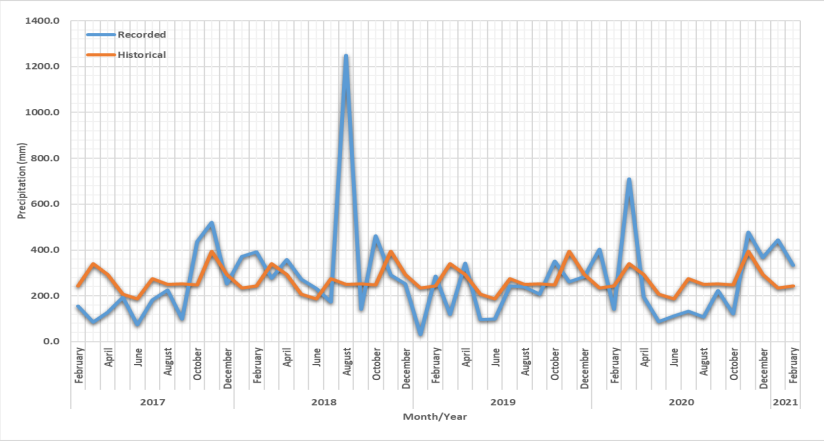

Figure A1. Measured (blue) and mean historical (red) monthly precipitation at the WPG Kipuka Field Test Site (red) during the field exposure.

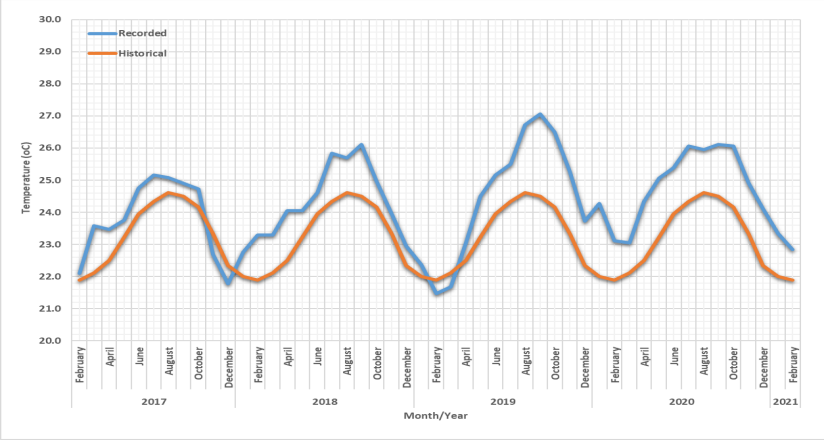

Figure A2. Measured mean (blue) and mean historical (red) monthly temperature at the WPG Kipuka Field Test Site (red) during the field exposure.

Table A2. Exposure and Inspection History of Specimens Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI

Test Site	Project#	Project Name	Test Method	WPG SOP	Specimen Type	Installation/Renewal Date	Inspection Date
Kipuka	WPG180122C	Adding Value to Small-Diameter Hazardous Fuels Through Thermal Modification (AWPA E9)	AWPA E9	535	L-Joints	February 2018	
	36						Feb' 2021
	24						Feb' 2020
	12	Hurricane Lane (August 22- 26, 2018)					Feb' 2019

Appendix B: Above Ground Decay Test Data

Table B1. Mean Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122C)

L-Joints	Type	25	26	27	28	25	26	27	28	25	26	27	28
	Species	Eastern Hemlock			Southern Pine	Eastern Hemlock			Southern Pine	Eastern Hemlock			Southern Pine
	Thermal Modification (°C)	180	170	N/A	N/A	180	170	N/A	N/A	180	170	N/A	N/A
February	Exposure (Months)	Mean Combined Decay Rating[a]				Mean Mortise Decay Rating				Mean Tenon Decay Rating			
2018	0	Installed											
2019	12	10	9.1	8.9	9.0	10	9.5	9.0	9.1	10	9.1	8.9	9.0
2020	24	9.6	6.2	6.5	8.3	9.6	7.1	6.5	8.5	9.7	6.2	6.5	8.3
2021	36	8.8	5.3	4.7	6.2	8.8	5.8	4.7	6.2	9.2	5.3	4.9	6.2
February	Exposure (Months)	Standard Error											
2018	0	Installed											
2019	12	0.0	0.3	0.2	0.1	0.0	0.2	0.2	0.2	0.0	0.3	0.2	0.1
2020	24	0.2	1.1	0.3	0.3	0.2	1.1	0.3	0.3	0.2	1.2	0.3	0.3
2021	36	0.2	1.1	0.9	1.1	0.2	1.1	0.9	1.1	0.2	1.2	0.9	1.1

[a] Combined values are the lower of the mean decay or insect ratings for the mortise and tenon, which were evaluated separately.

Table B2. Mean Visual Insect Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122C)

L-Joints	Type	25	26	27	28	25	26	27	28	25	26	27	28
	Species	Eastern Hemlock			Southern Pine	Eastern Hemlock			Southern Pine	Eastern Hemlock			Southern Pine
	Thermal Modification (°C)	180	170	N/A	N/A	180	170	N/A	N/A	180	170	N/A	N/A
February	Exposure (Months)	Mean Combined Insect Rating				Mean Mortise Insect Rating				Mean Tenon Insect Rating			
2018	0	Installed											
2019	12	10	9.9	9.9	10	10	9.9	10	10	10	9.9	9.9	10
2020	24	10	8.9	9.5	9.2	10	9.1	9.5	9.2	10	8.9	9.5	9.4
2021	36	9.8	9.0	8.4	8.2	9.9	9.0	8.3	8.2	9.8	9.0	8.4	8.3
February	Exposure (Months)	Standard Error											
2018	0	Installed											
2019	12	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.0
2020	24	0.0	0.4	0.2	0.2	0.0	0.5	0.3	0.2	0.0	0.4	0.2	0.3
2021	36	0.1	0.4	0.3	0.4	0.1	0.5	0.4	0.4	0.1	0.4	0.3	0.4

[a] Combined values are the lower of the mean decay or insect ratings for the mortise and tenon, which were evaluated separately.

Table B3. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122C)

Type	Species	Eastern Hemlock		Thermal Modification (°C)		180		Preservative System		N/A		Target Retention (kg/m³)			N/A	
25	"P" Series	8481	8482	8483	8484	8485	8486	8487	8488	8489	8490	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI[a]	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	24	9	10	10	10	9	9	10	10	10	9	9.6	0.5	0.2	9.3	10
2021	36	8	8	9	9	9	9	8	9	10	9	8.8	0.6	0.2	8.4	9.2
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	36	10	10	10	10	10	10	10	10	10	9	9.9	0.3	0.1	9.7	10

Table B3. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122C) - *Continued*

Type	Species	Eastern Hemlock		Thermal Modification (°C)		170		Preservative System		N/A		Target Retention (kg/m³)			N/A	
26	"P" Series	8491	8492	8493	8494	8495	8496	8497	8498	8499	8500	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	9	8	10	10	10	10	9	10	9	10	9.5	0.7	0.2	9.1	9.9
2020	24	0	4	10	9	10	10	4	9	7	8	7.1	3.4	1.1	5.0	9.2
2021	36	0	M	6	8	8	7	0	9	7	7	5.8	3.4	1.1	3.6	8.0
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	9	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	24	6	7	10	10	10	10	9	10	10	9	9.1	1.4	0.5	8.2	10
2021	36	DF	M	10	10	10	9	6	10	9	8	9.0	1.4	0.5	8.0	10

Table B3. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122C) - *Continued*

Type	Species	Eastern Hemlock		Thermal Modification (°C)		N/A		Preservative System		N/A		Target Retention (kg/m³)			N/A	
27	"P" Series	8501	8502	8503	8504	8505	8506	8507	8508	8509	8510	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	9	10	8	9	9	9	10	9	8	9	9.0	0.7	0.2	8.6	9.4
2020	24	6	7	7	7	7	4	7	7	6	7	6.5	1.0	0.3	5.9	7.1
2021	36	4	4	8	4	7	0	6	7	0	7	4.7	2.9	0.9	2.9	6.5
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	24	10	10	10	10	9	8	10	10	8	10	9.5	0.8	0.3	9.0	10
2021	36	7	8	9	8	8	7	9	10	7	10	8.3	1.2	0.4	7.6	9.0

Table B3. Mortise Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122C) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)		N/A		Preservative System		N/A		Target Retention (kg/m^3)		N/A		
28	"P" Series	8571	8572	8573	8574	8575	8576	8577	8578	8579	8580	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										**10**	**0.0**	**0.0**	**10**	**10**
2019	12	9	10	9	10	9	9	8	9	9	9	**9.1**	**0.6**	**0.2**	**8.7**	**9.5**
2020	24	8	9	9	10	8	8	7	8	9	9	**8.5**	**0.8**	**0.3**	**8.0**	**9.0**
2021	36	0	8	8	10	7	7	0	6	8	8	**6.2**	**3.4**	**1.1**	**4.1**	**8.3**
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										**10**	**0.0**	**0.0**	**10**	**10**
2019	12	10	10	10	10	10	10	10	10	10	10	**10**	**0.0**	**0.0**	**10**	**10**
2020	24	10	9	10	10	9	8	9	9	9	9	**9.2**	**0.6**	**0.2**	**8.8**	**9.6**
2021	36	7	9	10	10	8	7	6	8	8	9	**8.2**	**1.3**	**0.4**	**7.4**	**9.0**

[a] Lower CI = Lower 95% Confidence Interval, Upper CI = Upper 95% Confidence Interval

Table B4. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122C)

Type	Species	Eastern Hemlock		Thermal Modification (°C)		180		Preservative System		N/A		Target Retention (kg/m^3)			N/A	
25	"P" Series	8481	8482	8483	8484	8485	8486	8487	8488	8489	8490	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI[a]	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	24	8	10	10	10	9	10	10	10	10	10	9.7	0.7	0.2	9.3	10
2021	36	8	9	10	9	9	10	9	9	10	9	9.2	0.6	0.2	8.8	9.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2020	24	10	10	10	10	10	10	10	10	10	10	10	0.0	0.0	10	10
2021	36	9	10	10	10	10	10	10	9	10	10	9.8	0.4	0.1	9.5	10

Table B4. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122C) - *Continued*

Type	Species	Eastern Hemlock		Thermal Modification (°C)		170		Preservative System		N/A		Target Retention (kg/m^3)			N/A	
26	"P" Series	8491	8492	8493	8494	8495	8496	8497	8498	8499	8500	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	8	7	10	9	10	10	9	10	8	10	9.1	1.1	0.3	8.4	9.8
2020	24	0	0	9	8	10	8	4	9	6	8	6.2	3.7	1.2	3.9	8.5
2021	36	0	0	6	9	8	8	0	9	6	7	5.3	3.8	1.2	2.9	7.7
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	9	10	10	10	10	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	24	7	7	10	10	10	9	8	10	9	9	8.9	1.2	0.4	8.2	9.6
2021	36	DF	DF	10	9	10	9	7	10	8	9	9.0	1.1	0.4	8.3	9.7

Table B4. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122C) - *Continued*

Type	Species	Eastern Hemlock		Thermal Modification (°C)		N/A		Preservative System		N/A		Target Retention (kg/m^3)			N/A	
27	"P" Series	8501	8502	8503	8504	8505	8506	8507	8508	8509	8510	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	9	9	8	9	10	9	10	8	8	9	8.9	0.7	0.2	8.4	9.4
2020	24	6	7	7	7	6	4	8	7	6	7	6.5	1.1	0.3	5.8	7.2
2021	36	6	4	7	6	6	0	0	6	7	7	4.9	2.7	0.9	3.2	6.6
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										10	0.0	0.0	10	10
2019	12	10	10	10	10	10	9	10	10	10	10	9.9	0.3	0.1	9.7	10
2020	24	10	9	9	9	10	9	9	10	10	10	9.5	0.5	0.2	9.2	9.8
2021	36	7	8	8	8	8	8	9	10	8	10	8.4	1.0	0.3	7.8	9.0

Table B4. Tenon Visual Ratings for Thermally Modified Wood Exposed in an AWPA E9 Test at the WPG Kipuka Field Test Site near Hilo, HI. (Project WPG180122C) - *Continued*

Type	Species	Southern Pine		Thermal Modification (°C)			N/A	Preservative System			N/A	Target Retention (kg/m^3)			N/A	
28	"P" Series	8571	8572	8573	8574	8575	8576	8577	8578	8579	8580	Summary Statistics				
February	Exposure (Months)	Visual Decay Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										**10**	**0.0**	**0.0**	**10**	**10**
2019	12	9	10	9	9	9	9	8	9	9	9	**9.0**	**0.5**	**0.1**	**8.7**	**9.3**
2020	24	7	9	8	10	8	8	7	8	9	9	**8.3**	**0.9**	**0.3**	**7.7**	**8.9**
2021	36	0	8	8	9	7	7	0	7	8	8	**6.2**	**3.3**	**1.1**	**4.1**	**8.3**
February	Exposure (Months)	Visual Insect Rating										Mean	STDEV	STDERR	Lower CI	Upper CI
2018	0	Installed										**10**	**0.0**	**0.0**	**10**	**10**
2019	12	10	10	10	10	10	10	10	10	10	10	**10**	**0.0**	**0.0**	**10**	**10**
2020	24	10	10	9	10	9	7	9	10	10	10	**9.4**	**1.0**	**0.3**	**8.8**	**10**
2021	36	7	10	8	10	8	7	7	8	8	10	**8.3**	**1.3**	**0.4**	**7.5**	**9.1**

[a] Lower CI = Lower 95% Confidence Interval, Upper CI = Upper 95% Confidence Interval