



Moisture Monitoring Results in an R-40 Wall

Building America Webinar 2014
High Performance Enclosure Strategies



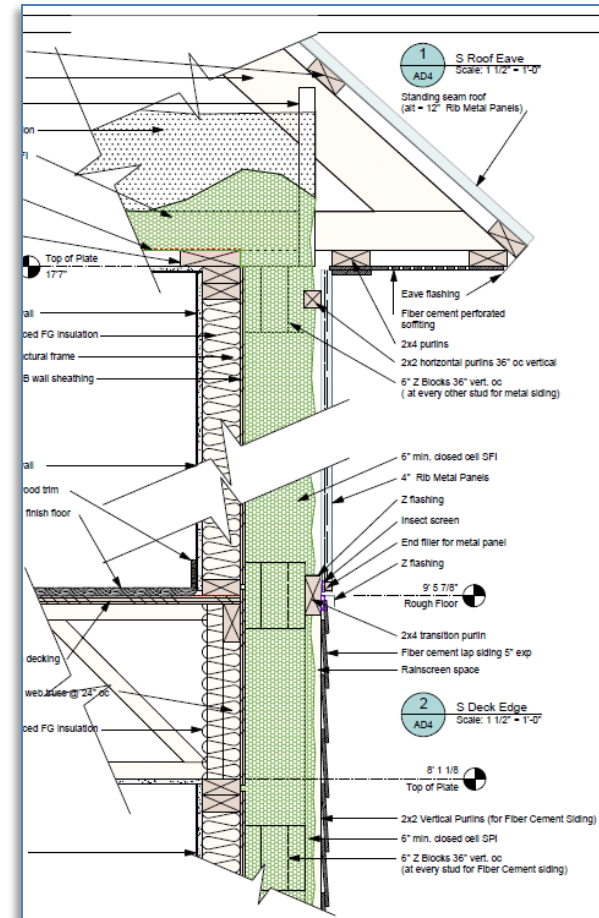
Overview of Presentation

- Reasons for Research
- Research Overview
- Results
- Recommendations
- Future Work



Reasons for Research

- Changes in construction due to:
 - Drastic increase in retrofit activities
 - Programs like PH & NZEH challenges
 - Increased use of hybrid insulation strategies
 - New insulation products
 - Code changes

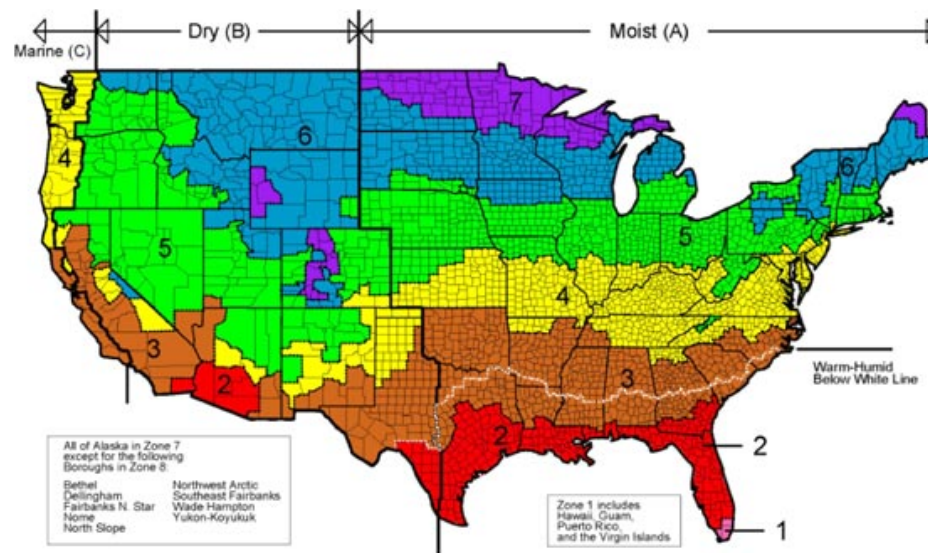


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Research Focus

- Climate zones 4 through 7
 - experience both cooling and heating seasons
 - considerable humidity during the summer



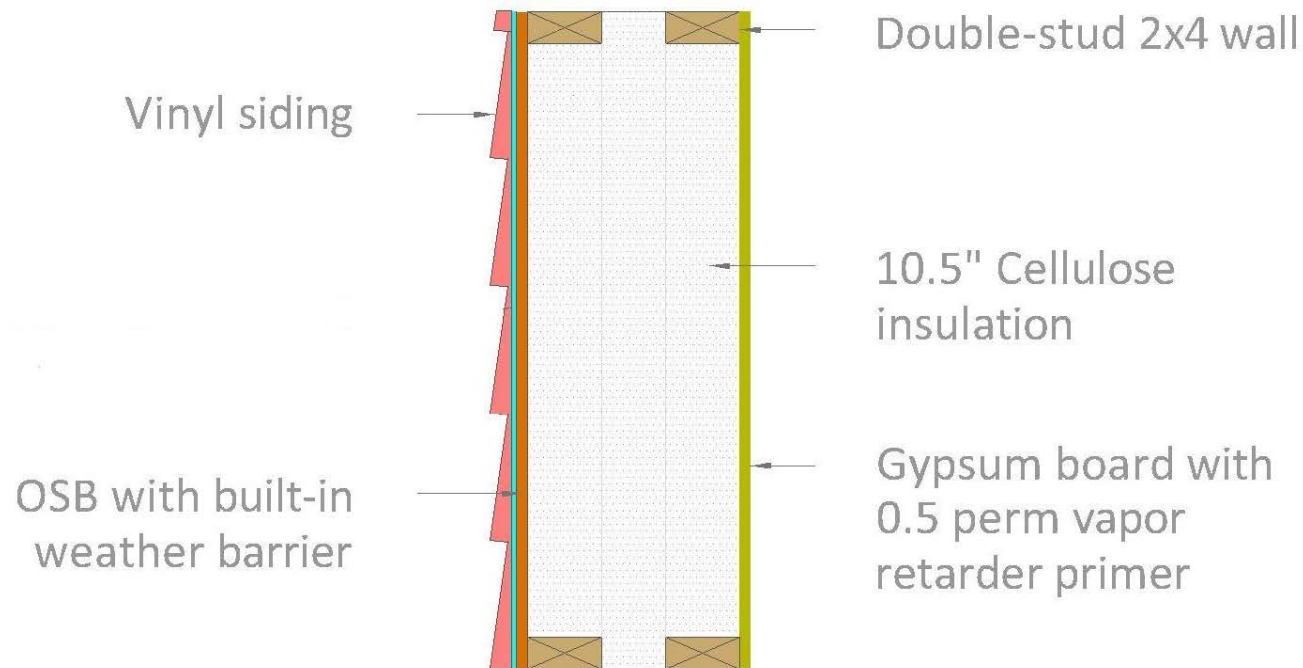


Technical Approach

- Modeling w/ WUFI & THERM
- Field testing – moisture content of components at start of construction
- Long term monitoring – moisture levels, RH & temperature at various points in the walls
- Comparison of modeling & field data
- Evaluate against accepted failure criteria



Assembly Evaluated



- NOTE: Exterior sheathing and studs in outer wall will be cold since they are "outside" the insulation



CRITERIA USED



Failure Criteria

- Total Water Content of Assembly
- Moisture Content (MC)
- Condensation
- Mold growth

- Both predicted & actual data was analyzed.

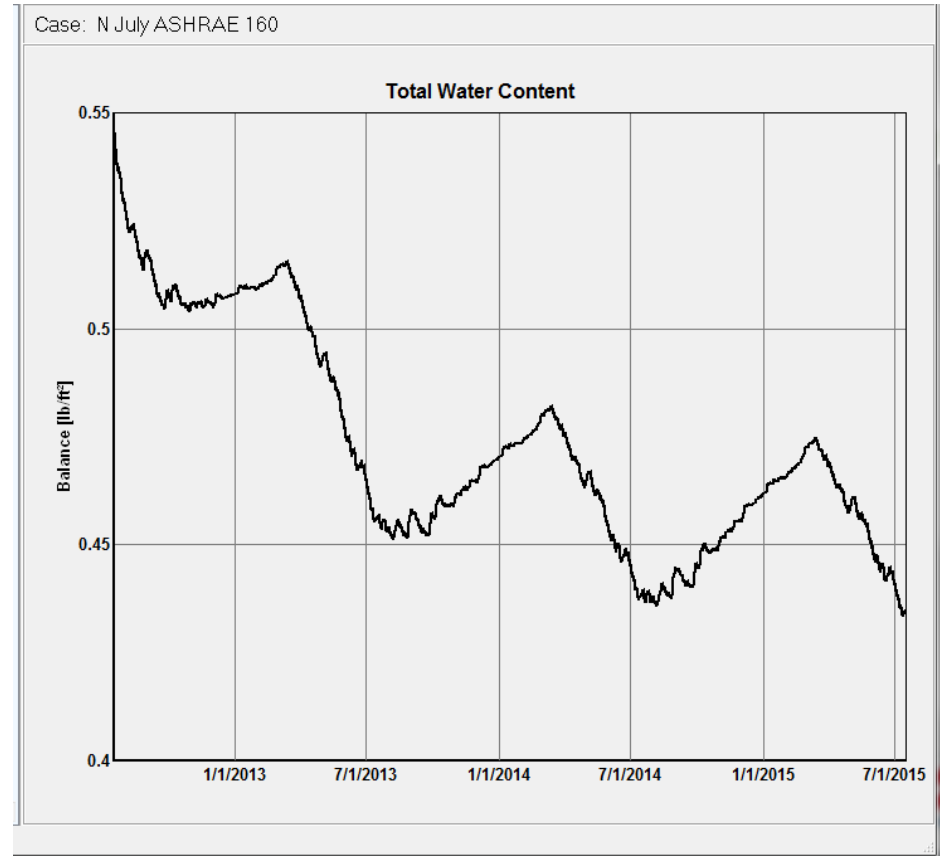


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Failure Criteria: Total Water Content



☑ Total water content of assembly decreases w/ time

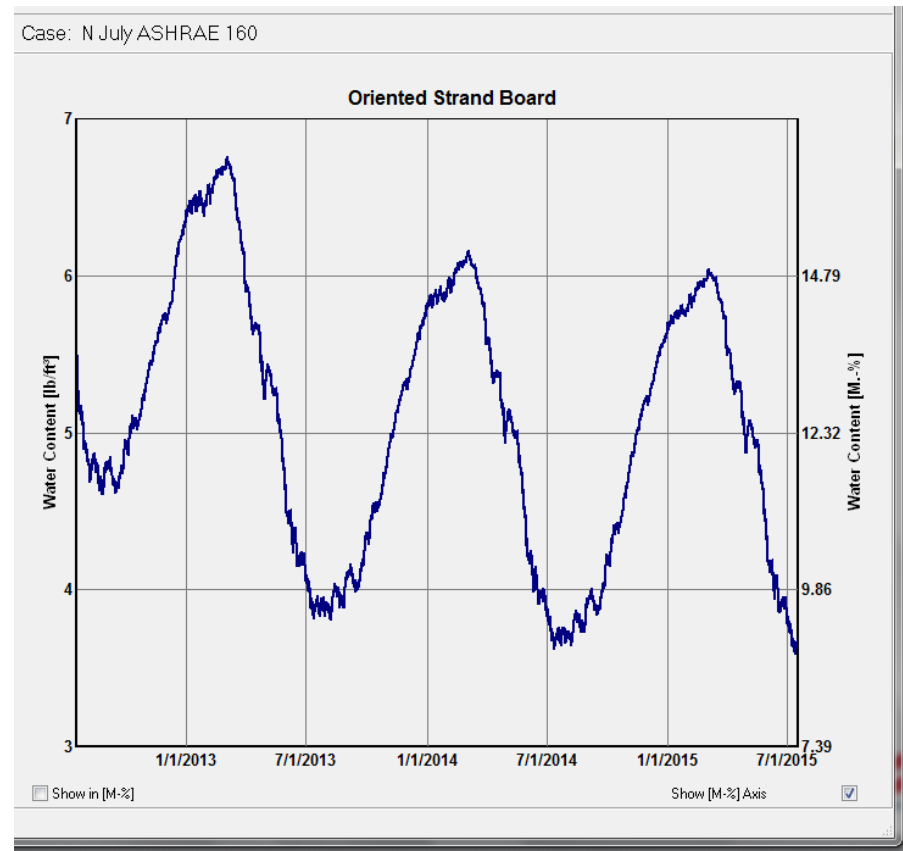


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Failure Criteria: Moisture Content

☑ Moisture Content (MC) of wood components $<$ 20%

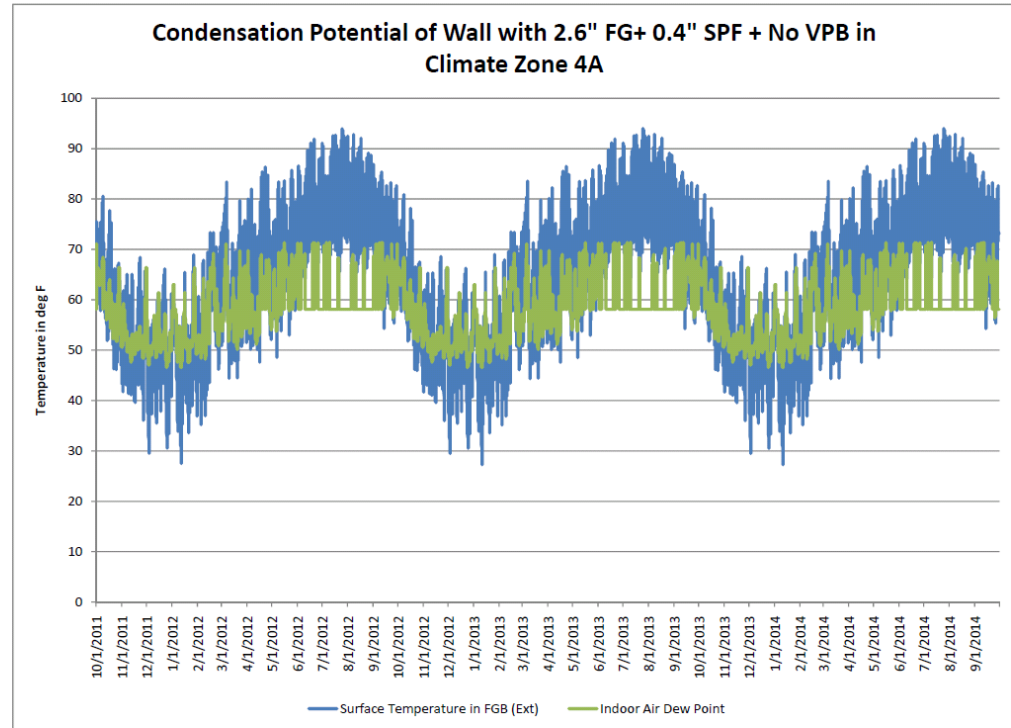


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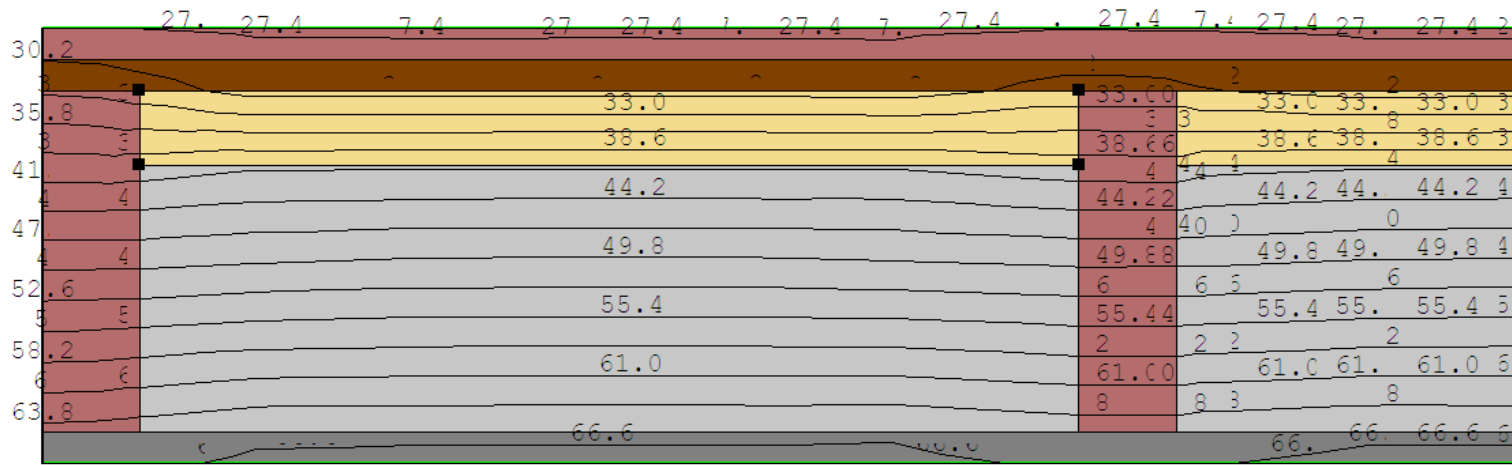


Failure Criteria: Condensation Potential

☑ Surface temp > interior air dew point temp



Failure Criteria: Condensation Potential

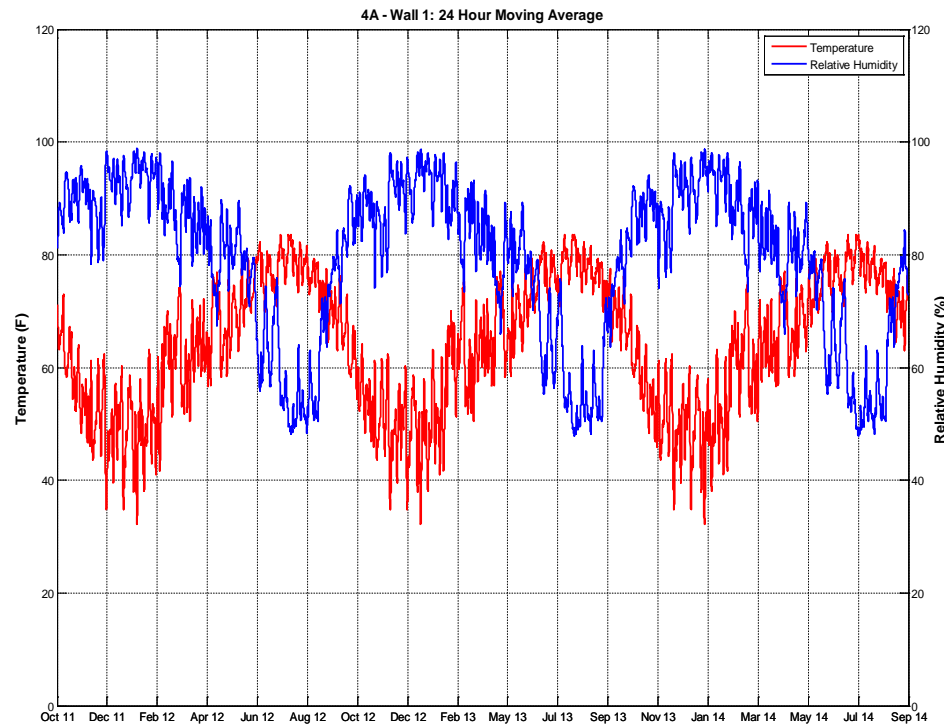


- Ambiguous – what % of time is surface below dewpoint?
- Several interfaces analyzed – OSB/foam, foam/cavity insulation, interior surface of brick



Failure Criteria: Mold Growth

- ☑ ASHRAE Standard 160 performance criteria:
 - 30-day running average: surface RH < 80% when temp 41°F to 104°F

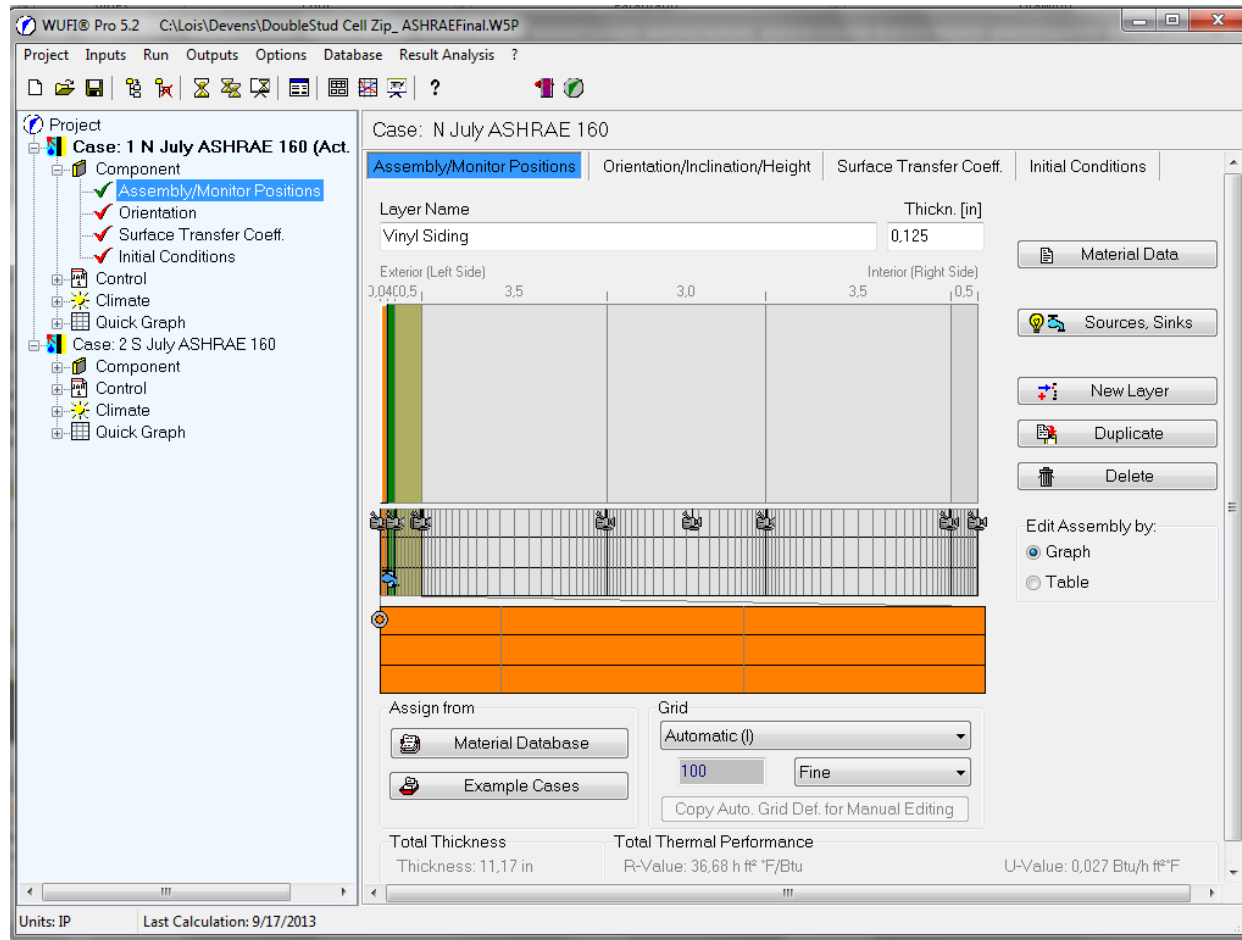




MODELING



Modeling - WUFI





Modeling - THERM

- WUFI can only analyze continuous components
- Want to analyze condensation potential due to thermal bridging at framing members - THERM

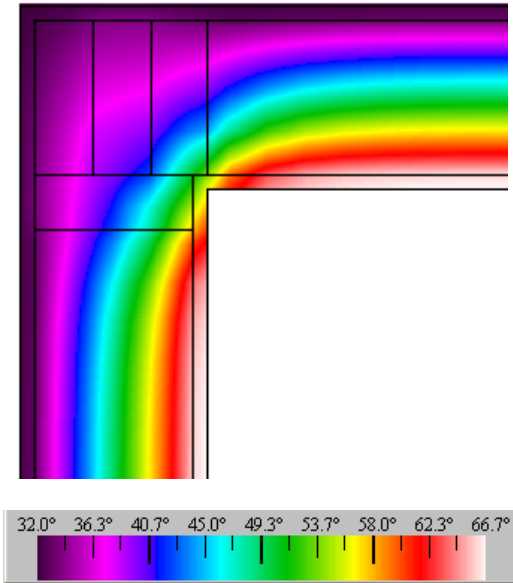


Image from THERM



FIELD TESTING/MONITORING



Test Home – Climate Zone 5A

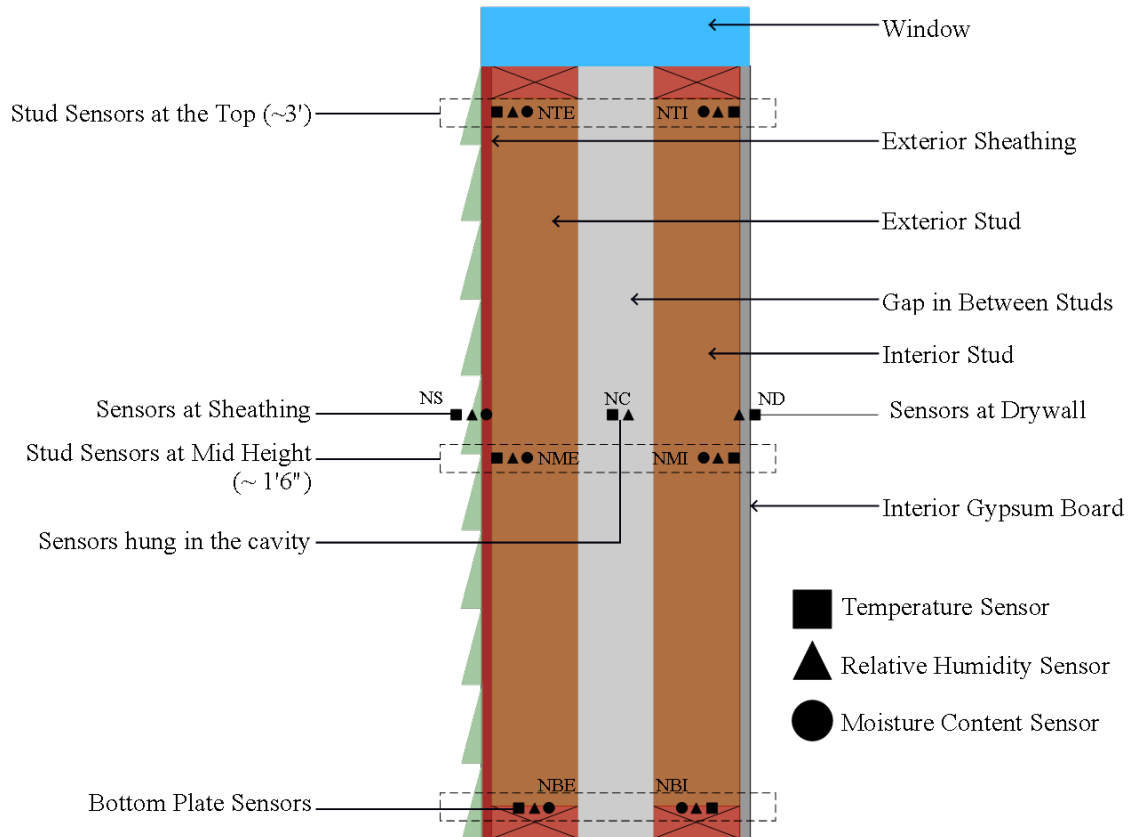
- North of Boston
- 1900 ft²
Townhome
- 10.5" double-stud walls
- Dense-packed w/ cellulose
- North & South walls tested



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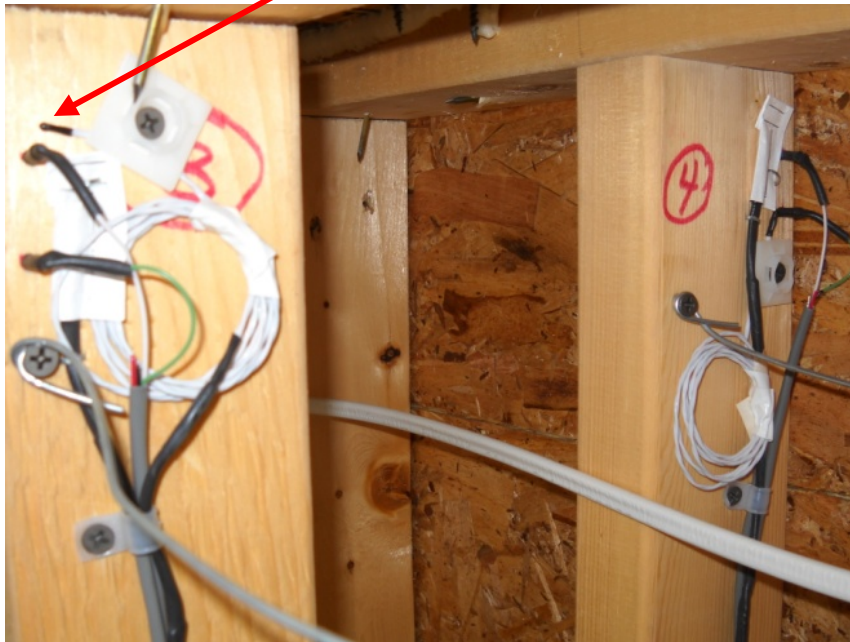
Sensor Locations



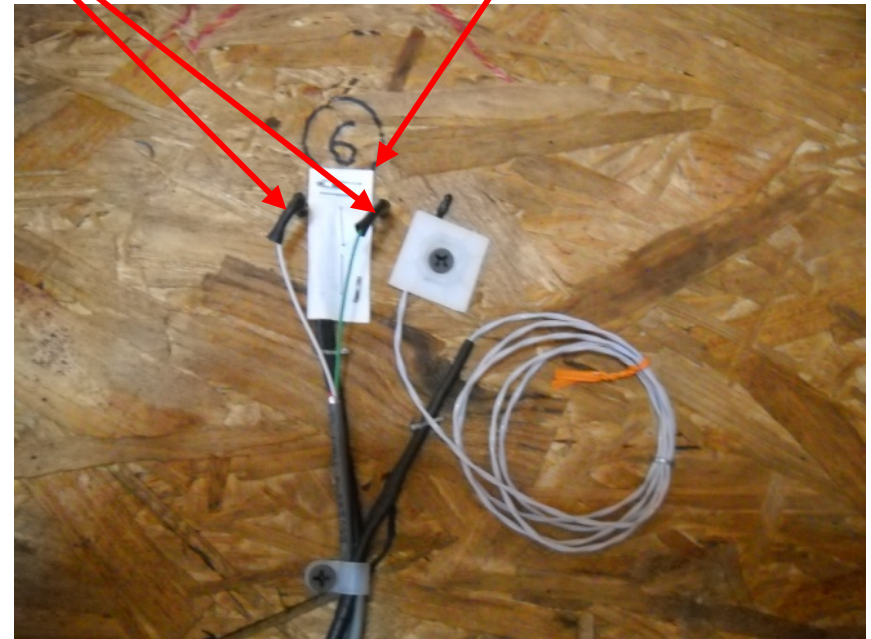


Sensors Used

Temperature
Sensor



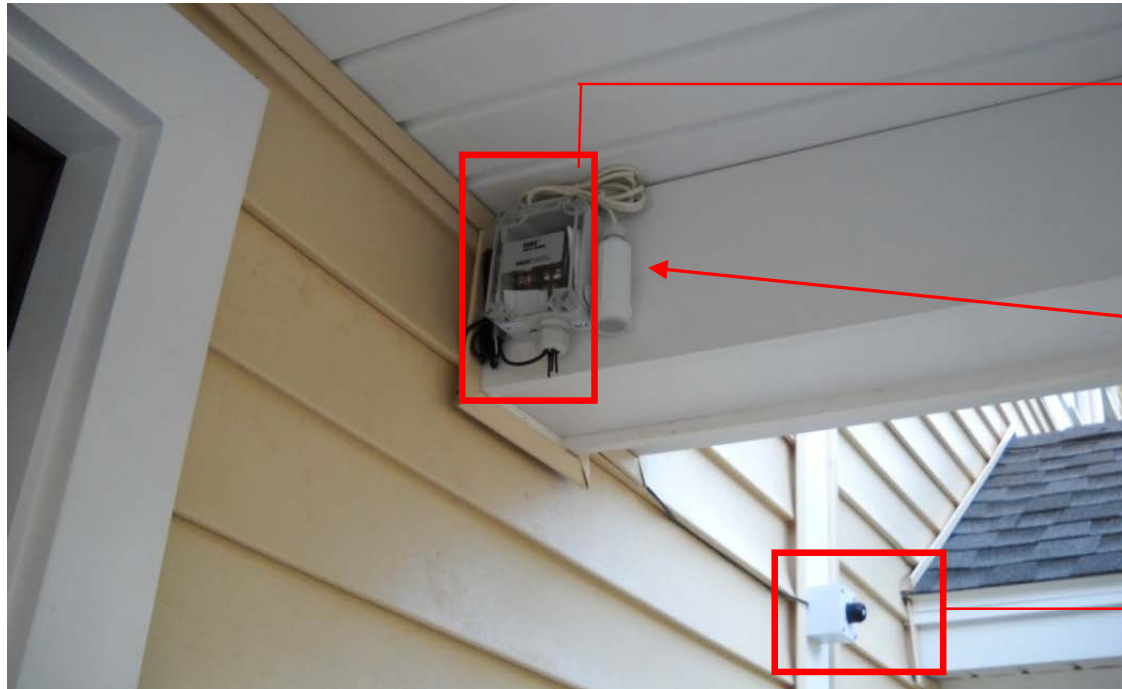
Moisture
Sensor Pins



Humidity Sensor with
Tyvek Covering



Exterior Sensors



Data logging equipment under porch overhang

HOBO sensor to collect exterior temperature and RH

Pyranometer located on the exterior side of the South bay



Initial Conditions

Level	Parameter Measured	Result
1 st Floor	Interior Temperature	78°F
	RH	69%
	Drywall MC	0.5 to 1%, no mold visible
Basement	Temperature	72°F
	RH	83%
	Stud MC	18%, mold visible



Initial Conditions



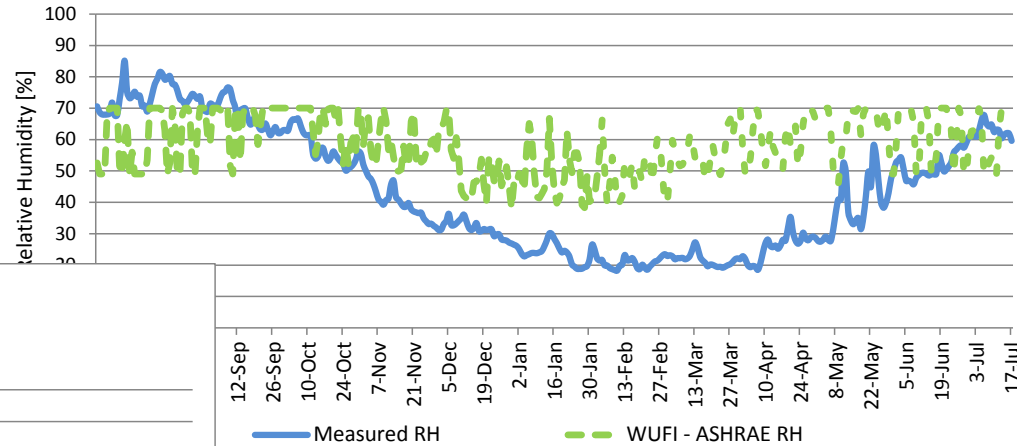


RESULTS

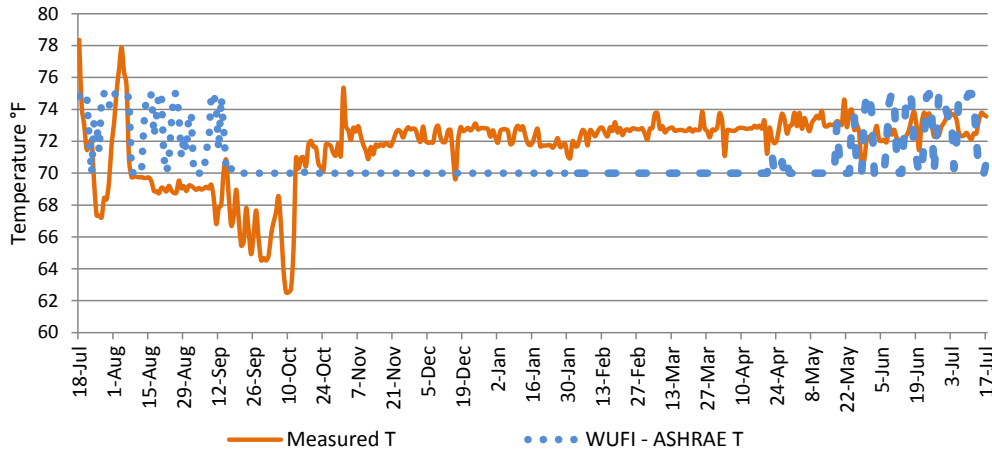


Interior Conditions

Indoor Conditions: Daily Average RH WUFI vs. Measured

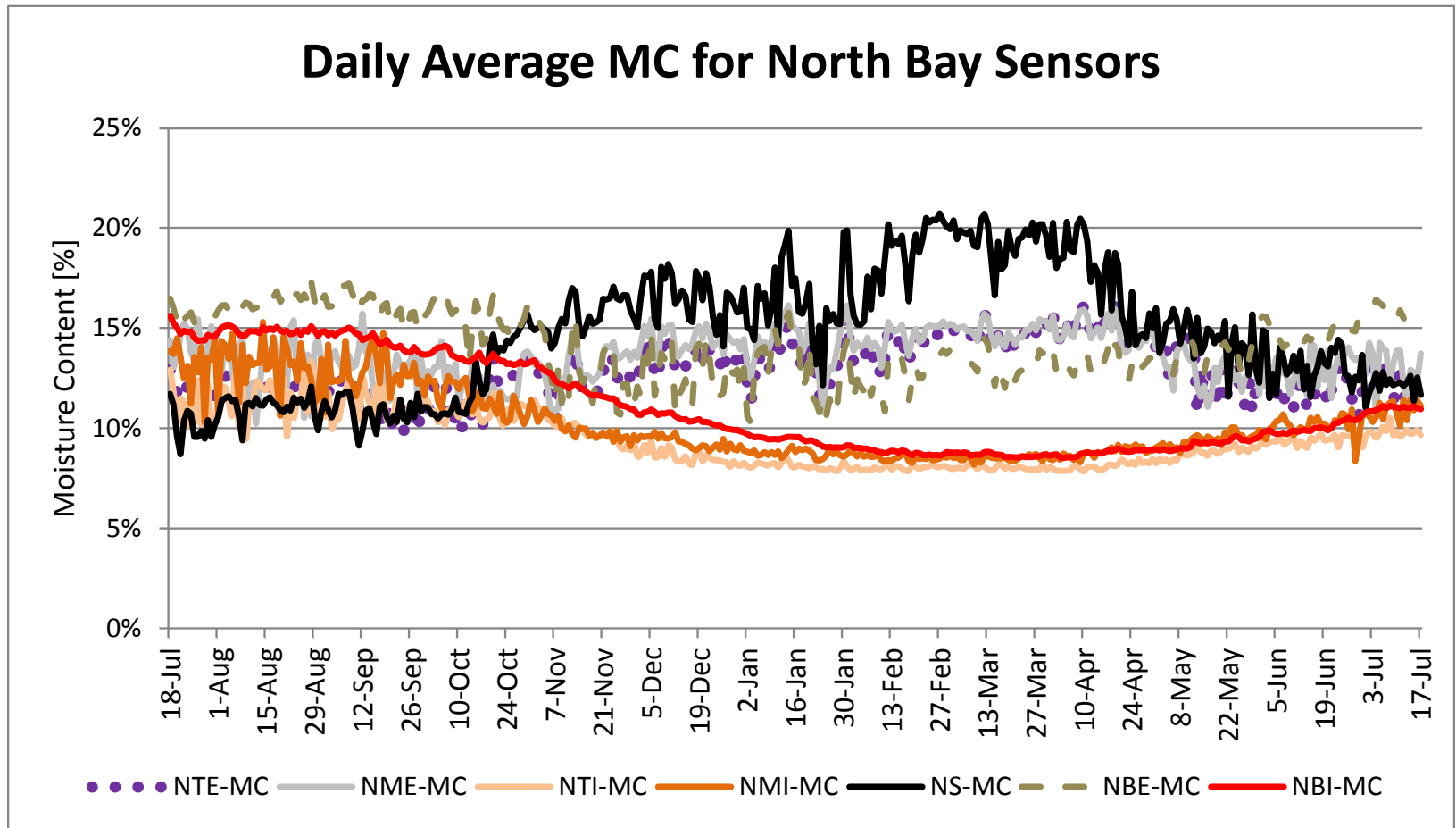


Indoor Conditions: Daily Average T WUFI vs. Measured





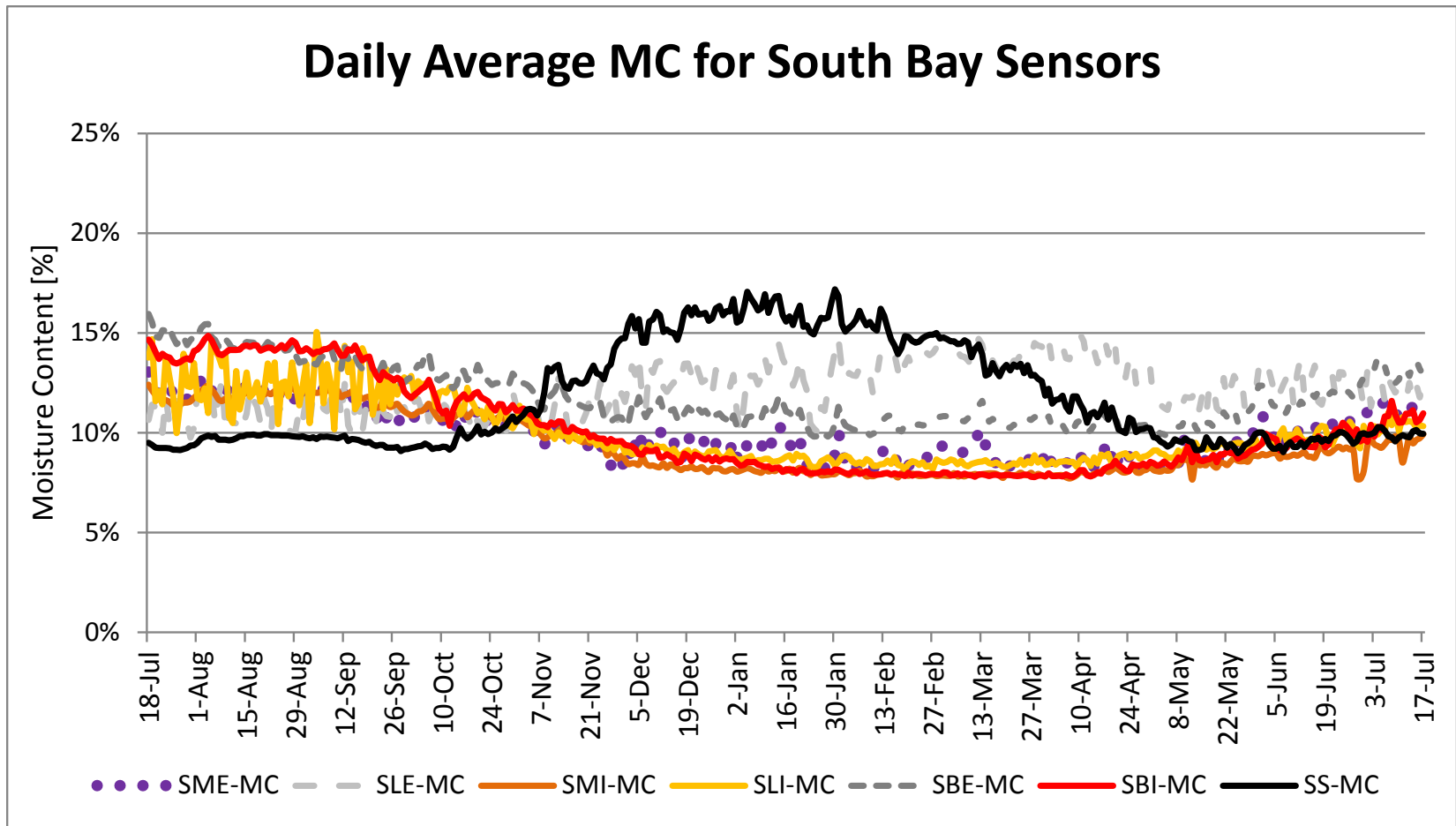
MC in North Studs



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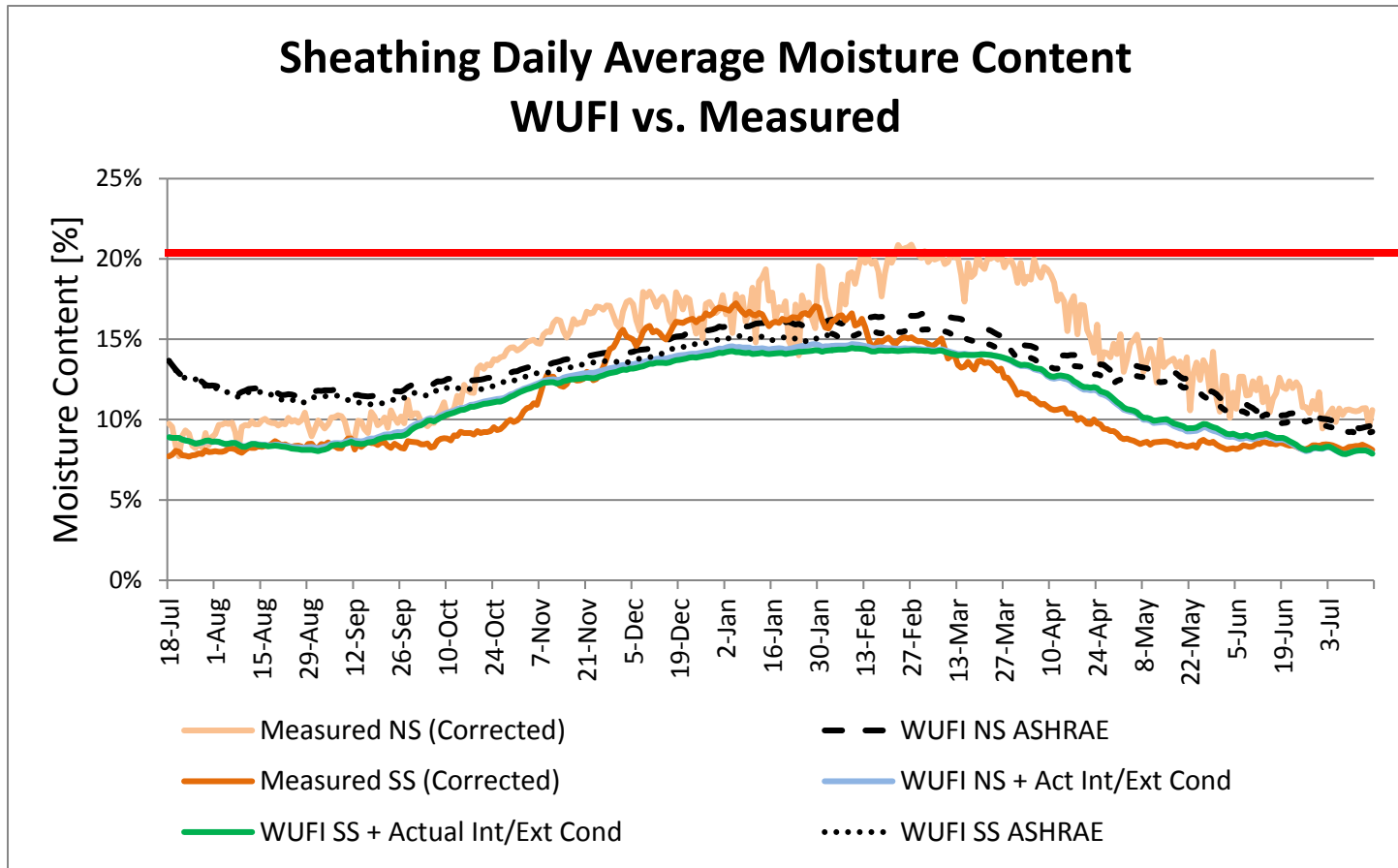
MC in South Studs



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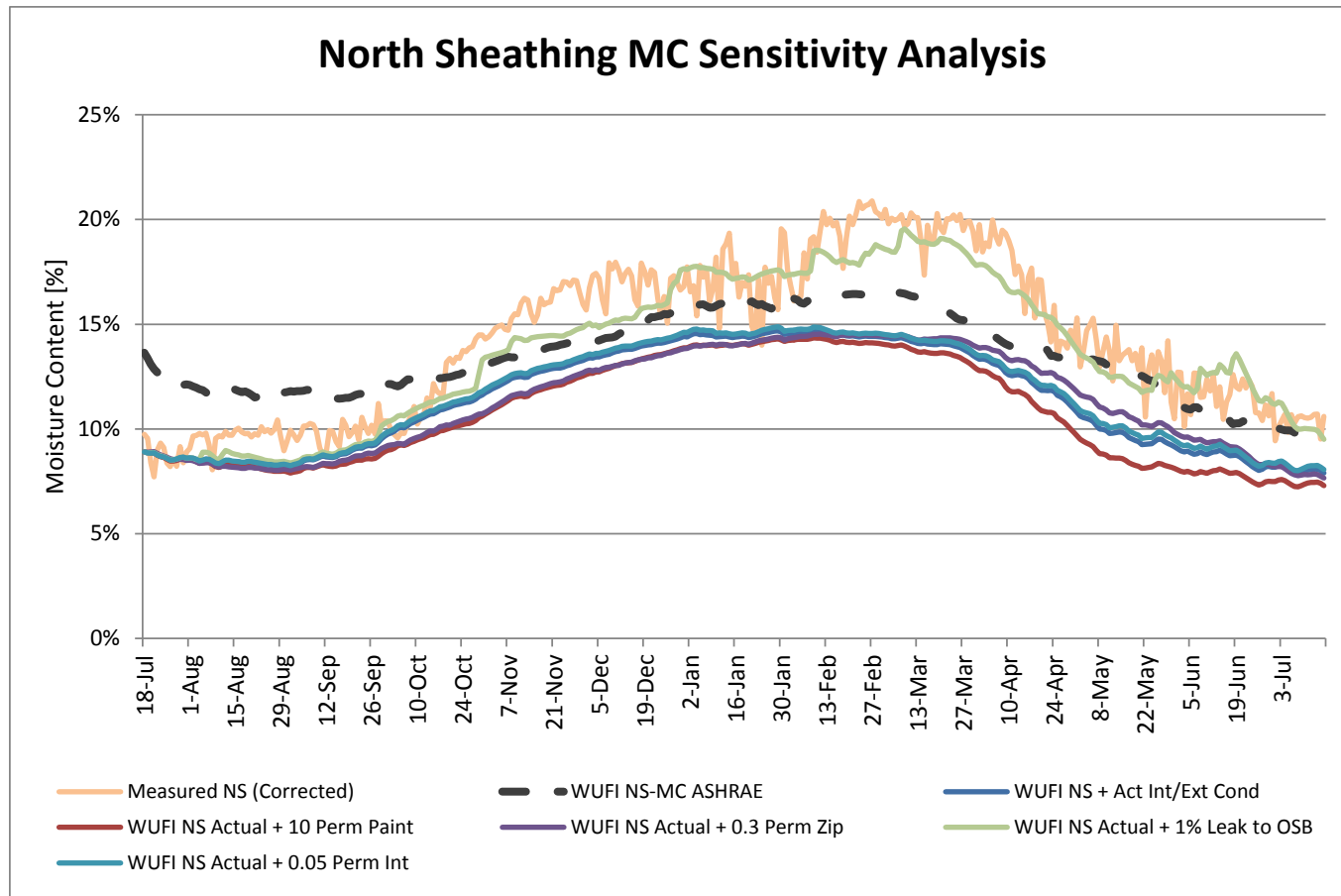
Predicted vs. Measured MC: OSB



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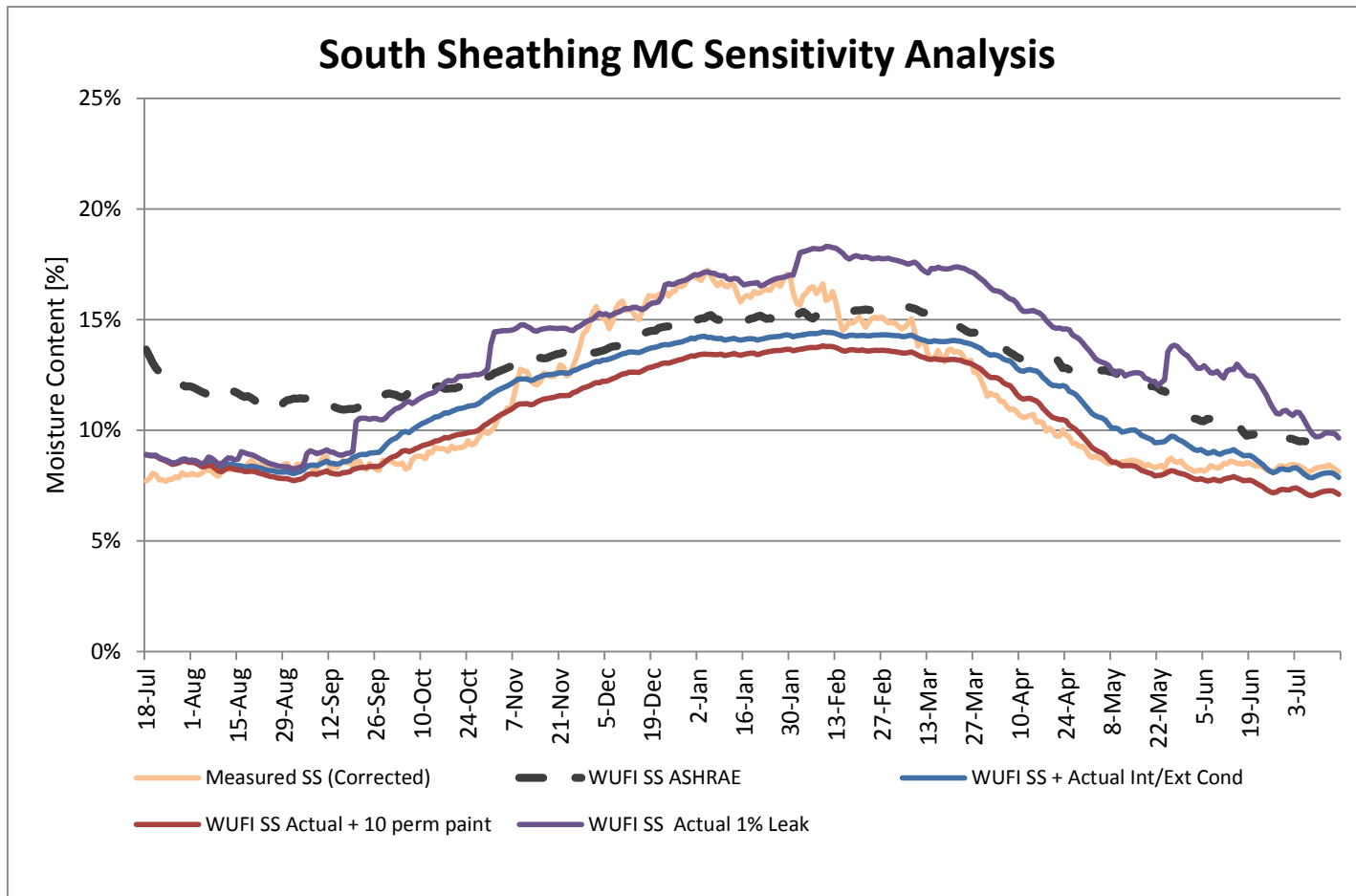


North OSB MC Analysis





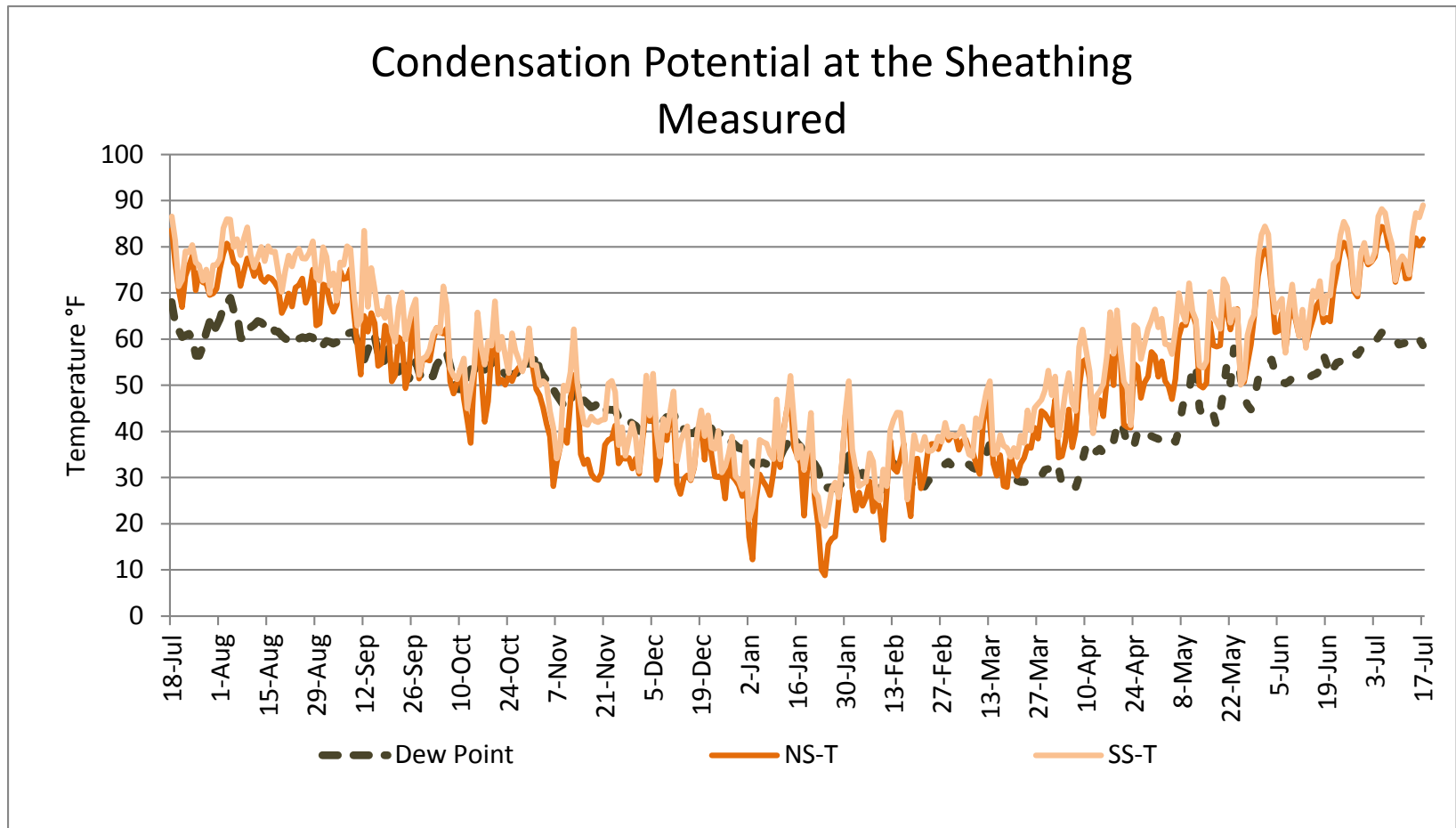
South OSB MC Analysis



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Condensation Potential



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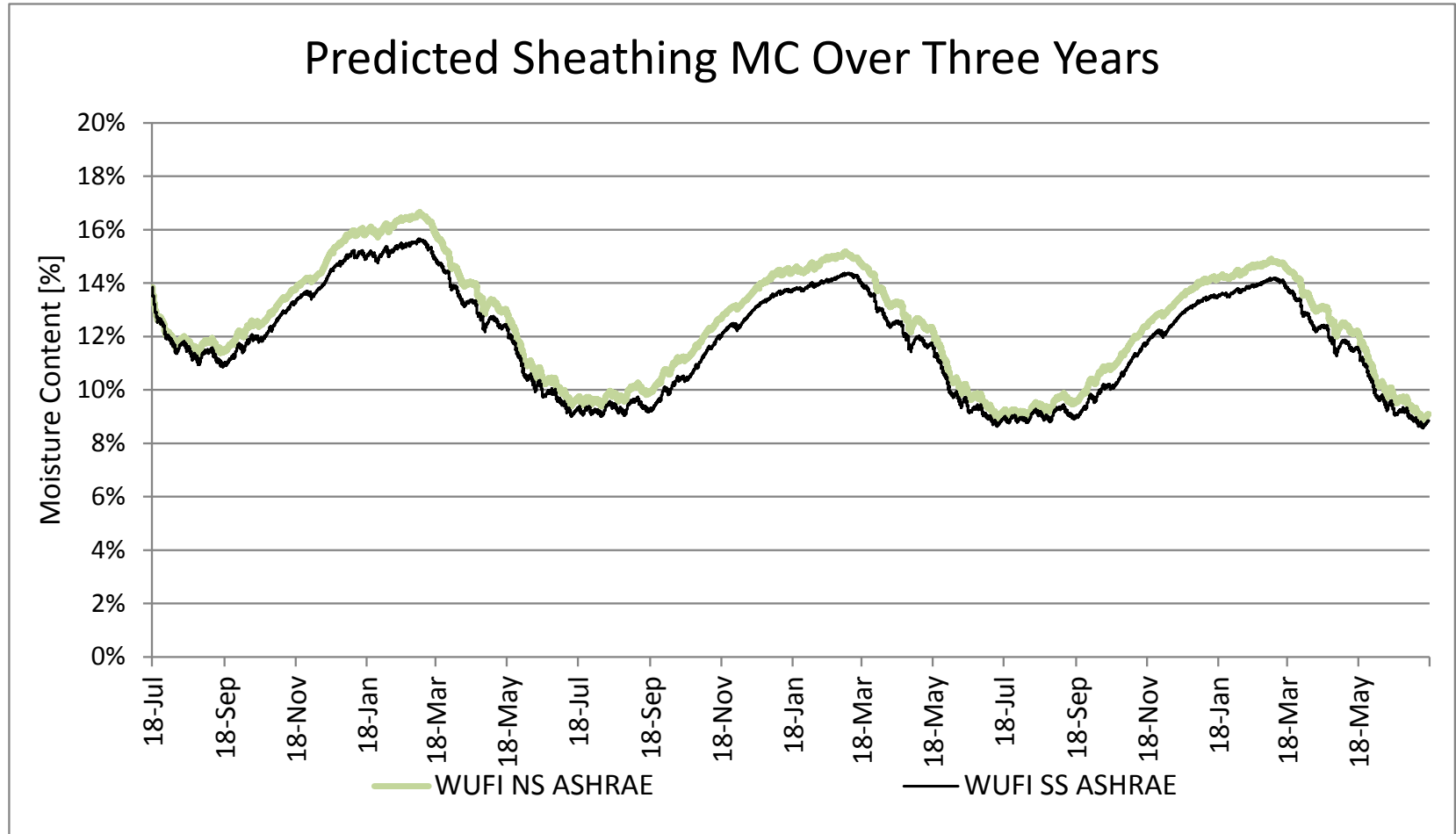
ASHRAE 160 Criteria

Orientation	Case	% of 30-day Averages that Fail (Jul – Mar) ¹	Pass/Fail
North	Measured	23%	Fail
	Predicted	36%	Fail
South	Measured	18%	Fail
	Predicted	54%	Fail

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Long Term Predictions



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Conclusions

- The assembly appears to be drying out annually.
- Measured data shows reasonable agreement with predicted peak MC levels using the ASHRAE 160 design criteria.
- Peak MC levels were slightly higher than predicted and reached approximately 21% in the North wall.



Conclusions

- Condensation potential is lower than predicted but still high.
- Both walls fail the ASHRAE 160 30-day criterion for mold growth.
- A parametric study indicates that the North bay may be experiencing moisture intrusion from driving rain.



Conclusions

- A more vapor open interior surface results in lower predicted peak MC levels.
- The wall assembly is predicted to perform well.
 - data in the South wall supports these findings,
 - data in the North wall suggests the performance is fair to good.



Recommendations

- If you have unusual materials or conditions - use WUFI and THERM to evaluate your projects on a case by case basis
- Prevent interior moisture from getting into walls
- Vented cladding is recommended for high-R walls when exterior rigid insulation is not part of the wall system
- Use several criteria for assessing success.



Future Work

- 2 double stud walls in Climate Zone 6 \approx 7000 HDD
 - 12" double stud cellulose wall
 - 12" double stud wall –
 - outer bay is 3.5" ccSPF
 - Remainder of cavity is dense pack cellulose



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QUESTIONS?