Energy Analysis of the Hughes Residence
272 Webbs Mills Road
Raymond, Maine 04071

48-315
Environment I : Climate and Energy
Elijah Hughes

Hughes Residence
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Project Summary and Site Introduction

The goal of this project is to analyze the current energy use of the Hughes Residence and how it is currently impacted by environmental conditions and how it could be impacted by simple building improvements.

Raymond, Maine is a heating climate and summers are often cool enough that cooling is not required. Its topography is gently sloped and contains several small freshwater lakes and ponds. Minimum lot size for residences in the Rural Residential Zone (RR) is two acres and therefore housing density is fairly low.

Raymond is densely forested with White Pines making the use of passive solar techniques very difficult during all seasons. Warm summer breezes come directly from the south while frigid winter winds come from the northwest.

The Hughes Residence is a hodge-podge of construction techniques and technologies, beginning as a 1-br residence constructed in 1955, it was modified and enlarged over time. It is fairly airtight, and most windows are double glazed. It is single-story with one portion that is two-story. It is a 2090 sq. ft. framed dwelling. The property is approximately two acres. The nearest neighboring dwelling lies approximately 80 ft. to the south.

Its program is arranged along a north-south axis with the majority of windows facing due west. To the west is also where the only opening in the trees is, that being the back yard. This allows sunlight to enter west facing windows. Despite a mild climate, west-facing spaces can be made unbearable during summer evenings.

Heating is provided by an oil fueled boiler, an oil fueled furnace, a wood fueled fireplace, and a wood fueled woodstove. Domestic hot water is provided by the oil fueled boiler. Water is drawn from an onsite drilled well. Electricity is pruchased from Central Maine Power.

There is a detatched two-car garage which is unconditioned and lies to the northeast. It recieves electrical service via an underground conduit.. The garage is in need of replacement as it leaks, is not properly sized for the large vehicles driven by the owners, and may have structural issues. It also includes an attached woodshed for storing firewood.

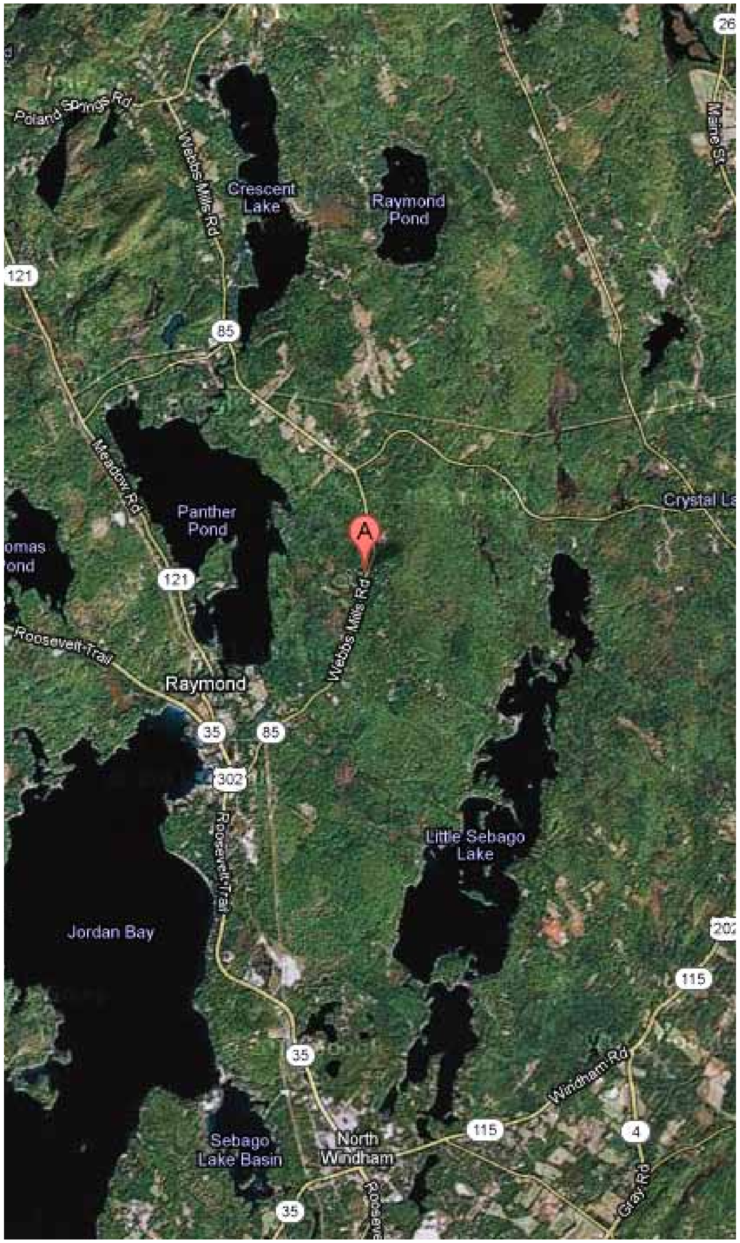
In 2007 the eastern side of the house was excavated so that the foundation could be resealed. Drainage pipes and stones were put back in place of the loam that was removed. The pipes drain approximately 30 ft. north of the dwelling into dense forest. Flooding has significantly decreased and is no longer an annual occurence.

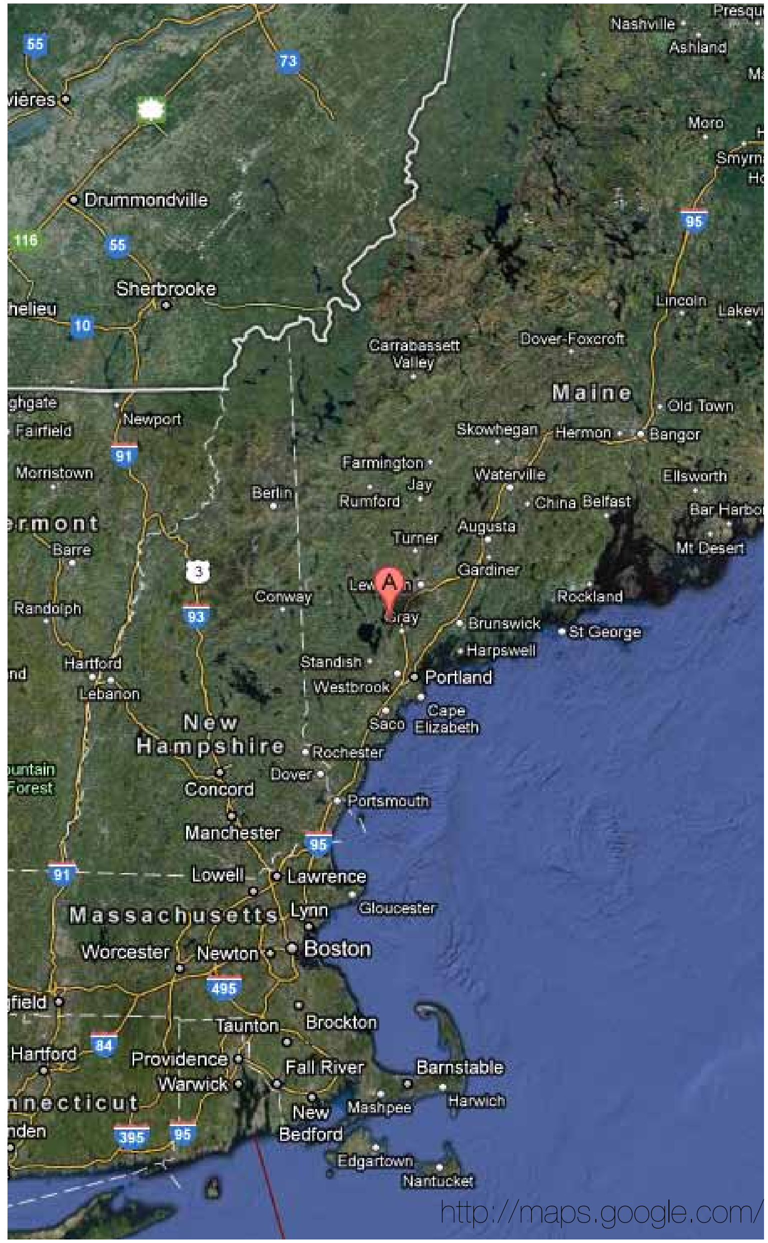
Description of Raymond, Maine
Description of dwelling

Scale: N/A

Location

Raymond 04071
Cumberland County, Maine





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Location

Driving time to relevent destinations

12 minutes North Windham
30 minutes Lewiston/Auburn
30 minutes Portland
60 minutes Conway, NH

1 hour 30 minutes
Portsmouth, NH
2 hours 30 minutes
Boston, MA
5 hours 30 minutes
Quebec, Canada
6 hours 30 minutes
New York, NY

12 hours Pittsburgh, PA

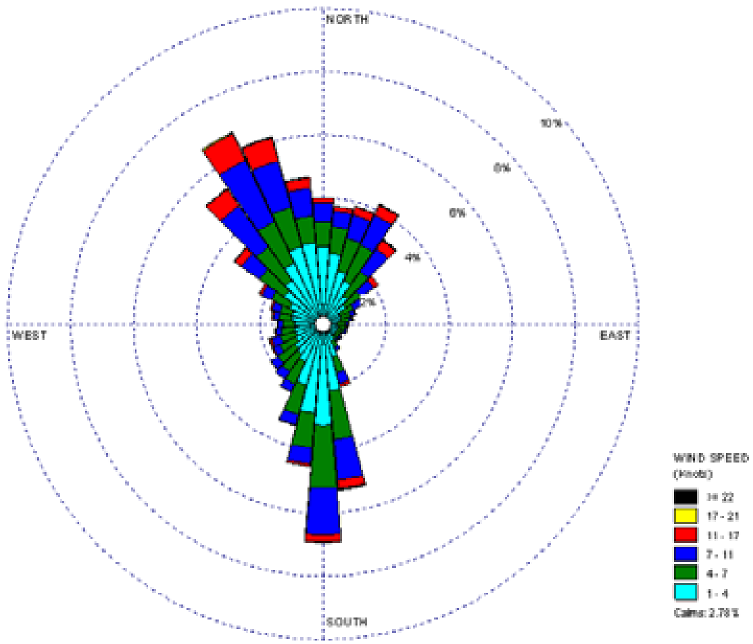
Scale: Multiple

PS.2

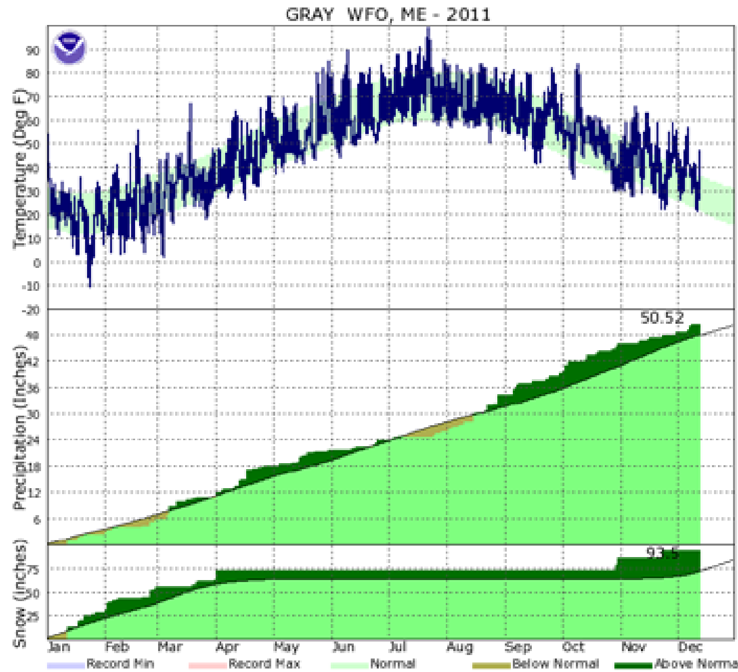
Climate Overview

Climatological data comes from two nearby sources.

1	National Weather Forecast Office, Gray, Maine	KGYX	9.3 miles to the east
2	Lewiston-Auburn Airport, Auburn, Maine	KLEW	11.4 miles to the northeast



5-year wind rose 2003-2007 [2]
Summer breezes from the south
Winter winds from the northwest



Temperature and Precipitation data 2011 [1]
Average summer temperatures between 55 and 80
Average winter temperatures between 10 and 30
Fairly moist/humid climate
No snow accumulation April-November

	Assets: Wind	Assets: Sun	Assets: Relative Humidity	Assets: Temperature	Liabilities: Wind	Liabilities: Sun	Liabilities: Relative Humidity	Liabilities: Temperature
Summer	✓	✓		✓		✓	✓	
Winter		✓			✓			✓

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Climate Overview

Data sources
5-year wind rose
Temperature and Precipitation data

Scale: N/A

PS.3

Images of the House


South Elevation


East Elevation


North Elevation


West Elevation

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Images of the House

Images from August 2011, courtesy Michael Hughes.

Scale: N/A

Occupancy Overview

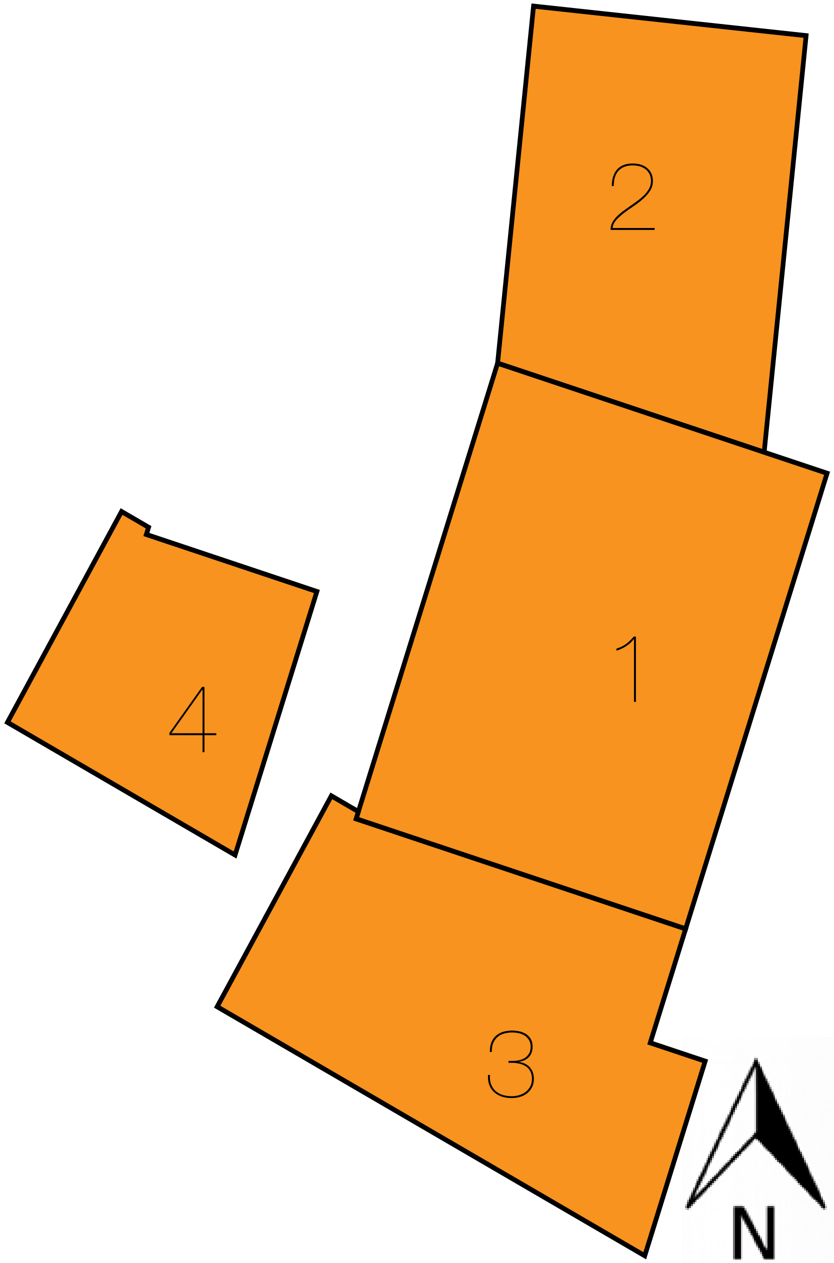
8 Rooms 3 Bedrooms 1 1/2 Bathrooms 2090 sq. ft.

zone2
built 1960s
poured in place full height basement
forced hot air
1 BR, 1/2 Bath, Laundry
495 sq ft

zone1
built 1955
concrete block crawlspace
hot water heat, wood burning stove
1 BR, 1 Bath, Kitchen, Dining
765 sq ft

zone4
built 2005
second story
hot water heat
1 BR
275 sq ft

zone3
built 1990s
concrete slab
hot water heat, wood burning fireplace
Living Room
555 sq ft



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Occupancy Overview

Dwelling layout
Dwelling use

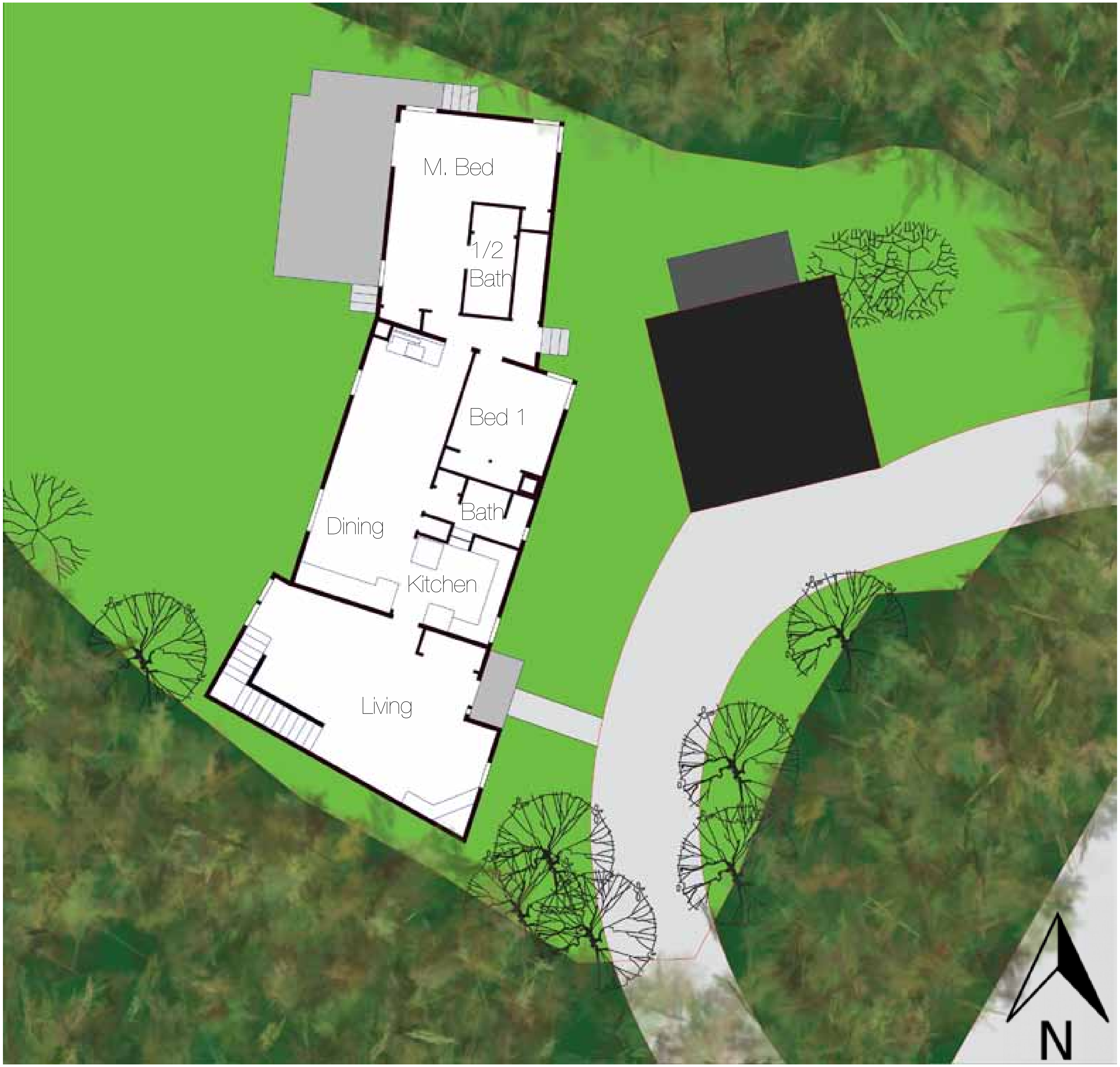
NOTE: Zones numbered in order of construction. Zones also correlate to heating zones. Zones 1, 3, 4 are heated by the hot water boiler, each on a separate circuit. Zone 2 is heated by the forced hot air furnace. Domestic hot water is also heated by the hot water boiler, and the domestic hot water tank is on its own circuit.

Scale: 1"=14'-0"

Site Analysis

The siting of this house may seem peculiar at first glance. It is aligned along a north-south axis which is less than ideal for a house in this climate. To understand why this is so, we should look to the surrounding forestry. In all directions we find first succession white pine growth of uniform height and maturity. This indicates that most of this land was clearcut. A network of handbuilt stonewalls indicates that this land was used as pasture. It stopped being used this way and was allowed to grow unatteneded about 60-70 years ago, around the time the house was constructed.

Whoever built the original piece of the house did not take into account tree growth and instead aligned the dwelling with the adjacent road. Further additions followed suit in building along this constraint rather than considering climatological effects on efficiency and comfort.



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Existing Site Plan

The dwelling is surrounded by dense white pine forest. There are sugar maples to the south-east, ashes on the corner of the unconditioned garage, and a large birch tree to the west.

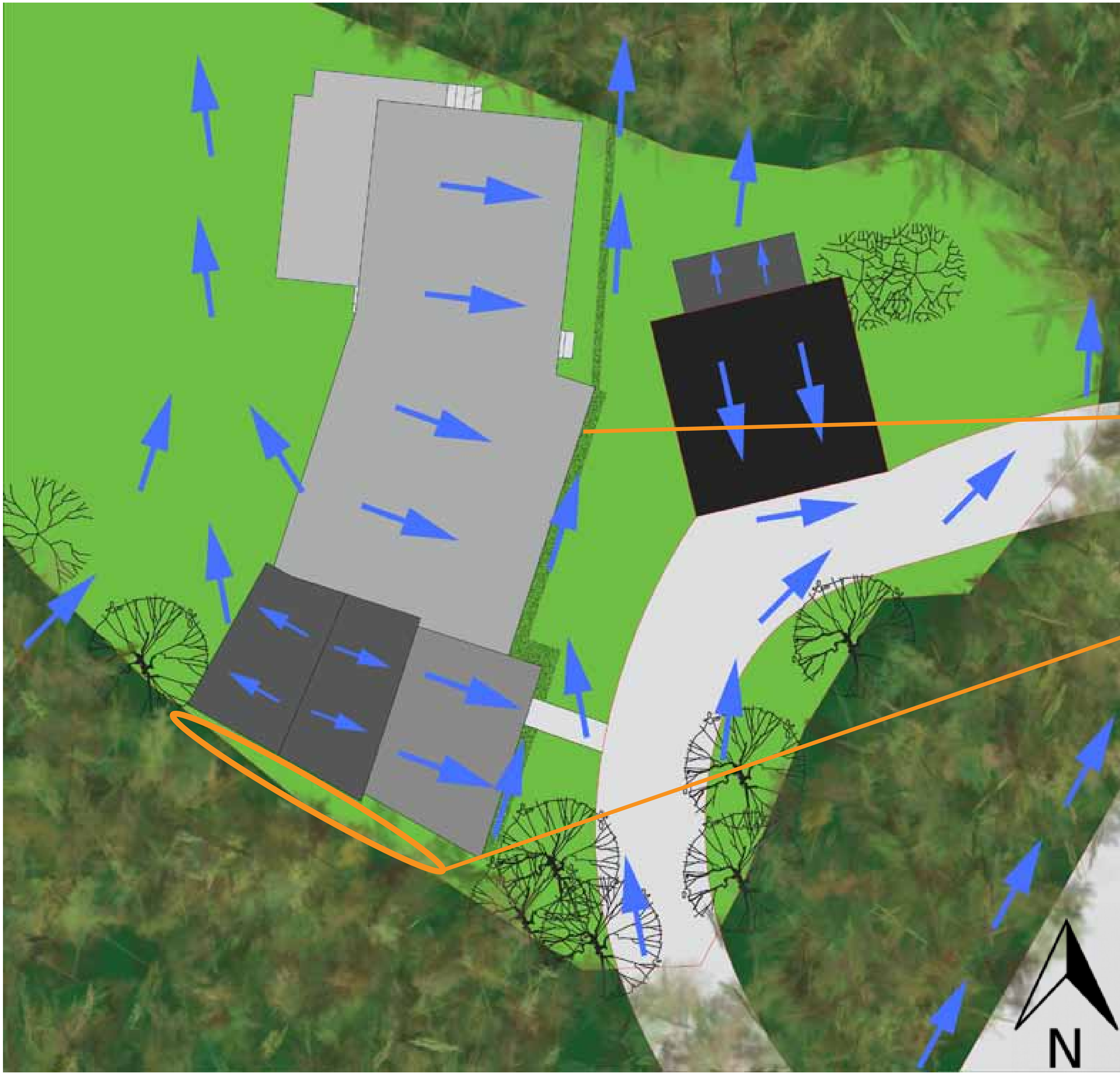
There is a woodshed attatched to the back of the garage for storing firewood.

Webbs Mills Road lies to the east and the driveway connects to it in two places.

The main entrance is off the living room and connects to the drive-way. Another entrance on the east side is no longer used and was installed when the house was used as a two unit dwelling. A large wooden deck is raised off the ground to the west adjacent to the master bedroom.

Scale: 1"=16'-0"

SA.2



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Surface Drainage

The site is well graded to allow water to drain away from the dwelling. Most water drains to the north where the ground slopes slowly downward at an approximate slope of 1:20.

Water from the majority of the roof collects in a gravel filled dripline which drains via a 4" perforated plastic drainage pipe. The pipe drains approximately 30 ft north of the dwelling into dense forest.

A problem occurs along the southern edge of the house, where water collects in heavy rain. This is not a major concern as it is not adjacent to a basement that can flood. The adjacent foundation is a poured concrete slab.

Scale: 1"=16'-0"

SA.3

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Winter Wind Conditions

Prevailing winter winds come from the northwest, with the exception of occaisional Noreaster storms which come from the southeast.

Despite the building catching the prevailing winter winds almost directly, they do not pose a significant problem as the dwelling is sheilded by dense evergreen growth.

Snow drifts are an indicator of strong prevailing winter winds and these rarely occur on this property.

Discomfort due to winter winds is only present in the master bedroom where there is a poorly insulated sliding glass door with an aluminum frame. It has an added storm door, also with an aluminum frame.

Scale: 1"=16'-0"

SA.4

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Summer Wind Conditions

Prevailing summer winds come directly and consistently from the south.

Winds are never significant here as the dwelling is sheilded by dense plant growth.

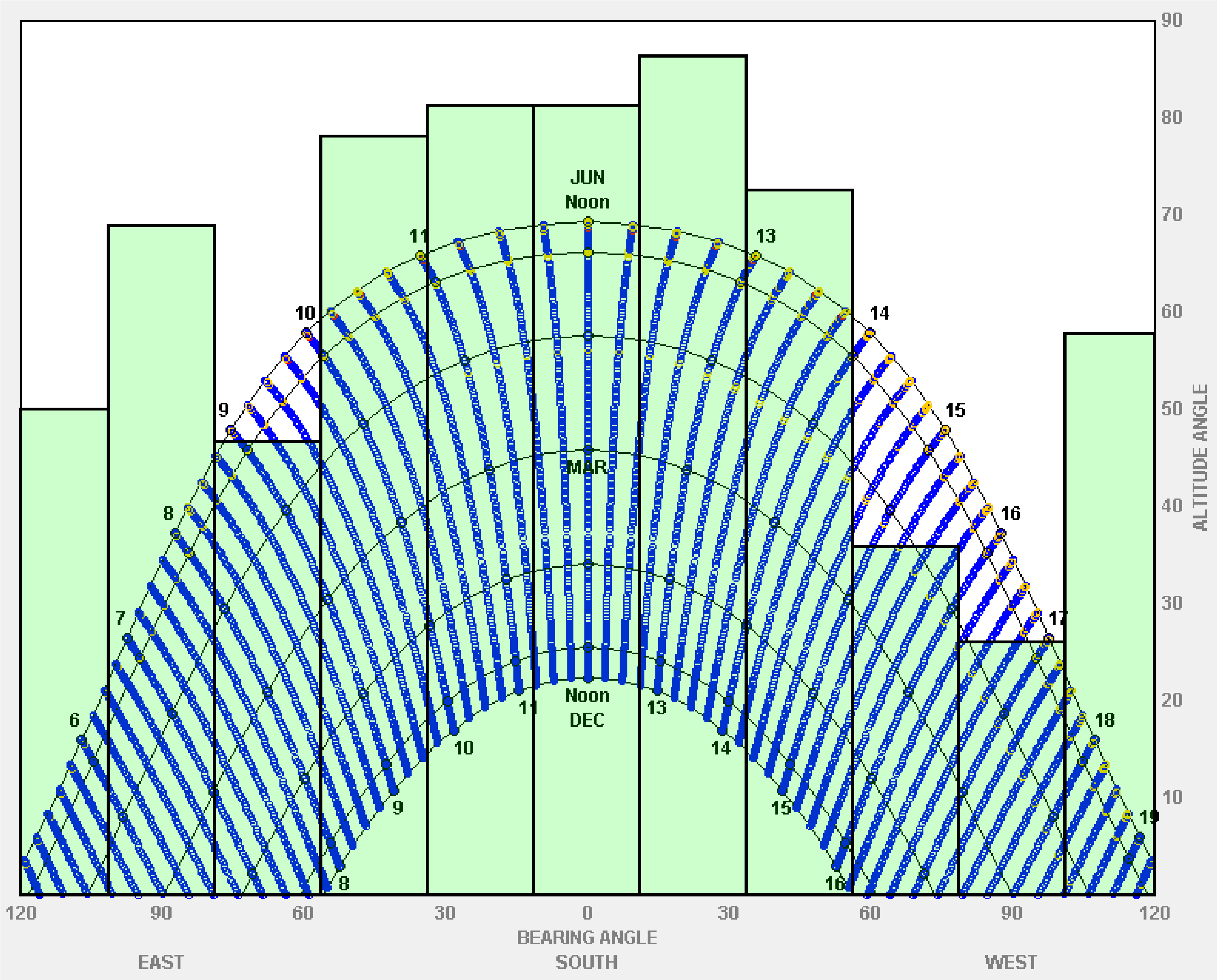
Currently the dwelling does nothing to take advantage of these consistent breezes to aid in air change and passive cooling. The only window facing due south is a double hung window on the second floor. There is a very large expanse of wall in the living room that could be punctured for both natural ventilation and natural light.

Scale: 1"=16'-0"

SA.5

Sun Path Diagram

Raymond, Maine



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Sun Path Diagram

A sunpath diagram of Raymond, Maine with tree obstructions mapped.

The house is largely in the shade. Direct sunlight makes it to the windows during the afternoons in the summer but is largely blocked year round.

While this may seem like it would make the house very dark during the winter months, reflected light from the snow illuminates the house well enough to forgo artificial lighting for the peak two hours of the day.

Tree cover is consistent year round due to forests being predominantly white pine and varieties of evergreen.

Scale: N/A

SA.6

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Winter Sun Conditions

Sun Conditions for December 21st, 9am, 12pm, and 3pm.

As indicated by the Sun Path Diagram (SA.6), the entire site is shaded by trees all day during December. The shadows cast by the house and the garage are created by light that filters through the trees.

The garage casts a shadow on the master bedroom at 9am. The alley between the house and the garage is shaded almost constantly, with the exception of midday. At midday and in the afternoon, the tall two-floor part of the dwelling casts a shadow on the rest of the home.

Area shaded by house:
9am 7565 sf
12pm 1786 sf
3pm 5271 sf

Scale: 1"=32'-0"

SA.7

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Summer Sun Conditions

Sun conditions for June 21st, 9am, 12pm, 3pm.

As indicated by the Sun Path Diagram (SA.6), a majority of the site is shaded by trees all day during June. The shadows cast by the house and the garage are created by light that filters through the trees.

A portion of the backyard gets nearly 4 hours of direct unfiltered sunlight.

Area shaded by house:

9am	1424	sf
12pm	122	sf
3pm	1023	sf

There is 82% less shaded area on the summer solstice than on the winter solstice from 9am-3pm.

Scale: 1"=32'-0"

SA.8

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Environmental Programming

I

Ideal conditions for each programmatic feature, based on use patterns.

Space	Sq. Ft.	Living, Circulation, or Support?	Time in Use	# People	MET 1-5	CLO 1-5	Internal Loads L/M/H	Env. Interests: Views/Access	Preferred Orientations SW	S	SE	E	NE	N	NW	W	Space Priority
Living Room	555	L/C	4:30-10 PM	1-5	1	.9	Medium	Views of Backyard	■	■	■						2
Kitchen	115	L/C	5:30-7 AM 4:30-8 PM	1-5	2	.9	High	Access to driveway		■	■	■					1
Dining Room	350	L/C	5:30-8 PM	1-5	1	.9	Low	Views of Backyard, Access to kitchen	■	■	■					■	2
Bathroom	65	S			1	0-.9	High	Centrally located									4
Bedroom 1	150	L	10 PM - 7 AM	1	1	.9	Low	Views of Backyard	■		■	■				■	3
Master Bedroom	285	L/C	10 PM - 7 AM	2-5	1	.9	Low	Views of Backyard	■		■	■				■	2
1/2 Bath	65	S			1	.9	Low	Access to Master Bedroom									4
Bedroom 2	265	L	10 PM - 7 AM	2	1	.9	Low	Views of Backyard	■		■	■				■	3

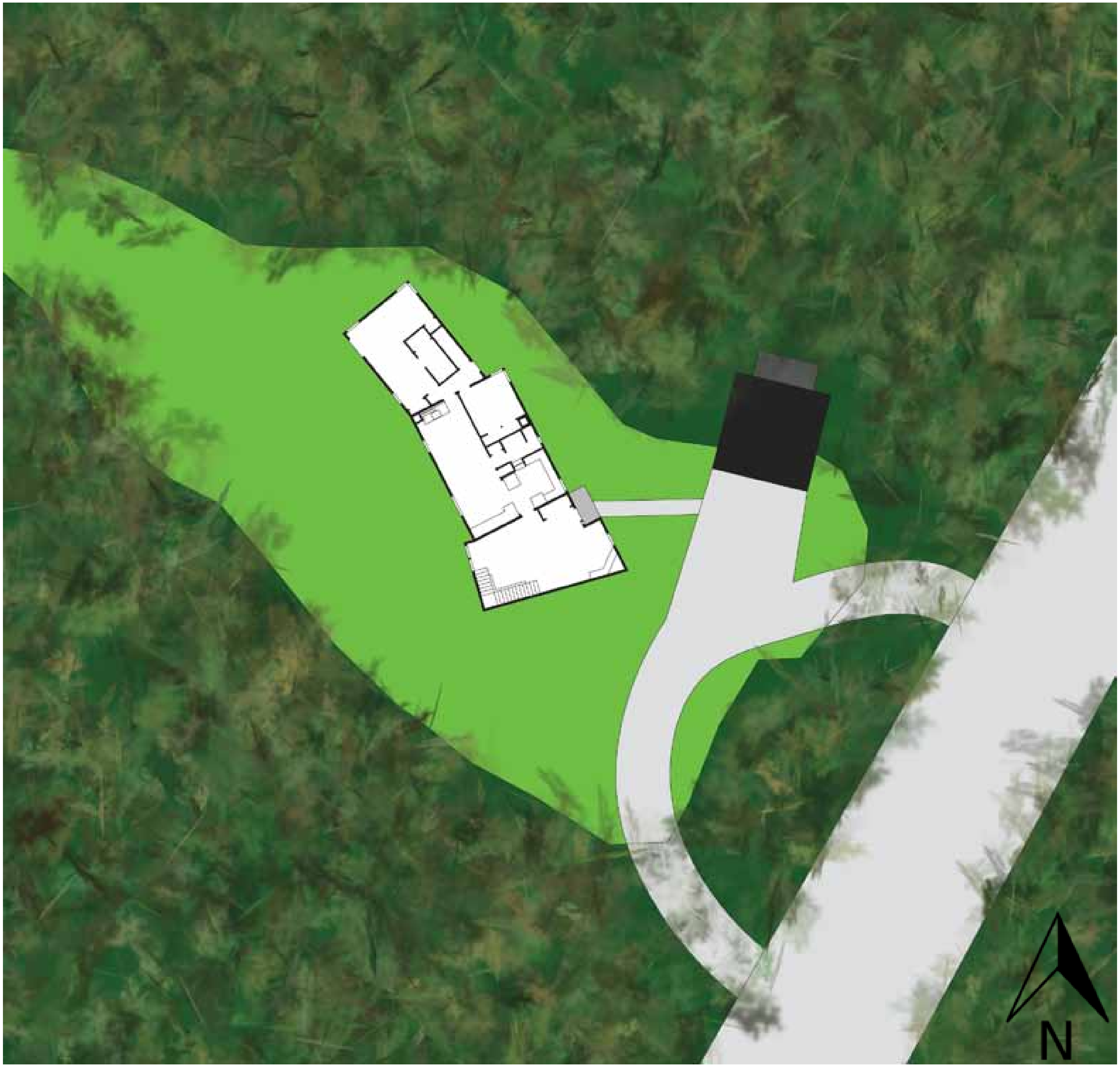
The house is currently lived in by a family of two adults, two high school age children, 1 large dog, and 1 cat. An older child goes to school elsewhere and visits for up to two weeks at a time. The family rarely hosts formal get-togethers aside from annual dinners. As the kitchen, dining room, and living room form a contiguous space for both living and circulation, none of them can be eliminated from the heated program.

Only Bedroom 1 can truly be cut off from heat, but it is currently on the same hot water circuit as the kitchen and dining room Zone 1 (PS.5). The Master Bedroom and Bedroom 2 could be closed off with the thermostat lowered 10 degrees when they are not in use. A programmable thermostat in those locations is needed for this to happen automatically. There is more than enough living space in the Living/Dining/Kitchen area for them to be used during the day so that the Master Bedroom and Bedroom 2 could be closed off.

Environmental Programming

How the house is lived in
Spaces that can be eliminated from heated area

Scale: N/A



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Ideal Site Plan

By twisting the dwelling 45 degrees and pushing the garage back into the woods, the dwelling would be able to recieve a great deal more sunlight while being shielded from harsh and strong evening light from the west.

Bedroom 1 and the Kitchen would still be able to recieve morning sunlight from the east. The living room, dining room, master bedroom, and bedroom 2 would receieve more sunlight from the south.

In this orientation, passive solar heating techniques such as a Trombe Wall or a Water Wall would be much more effective.

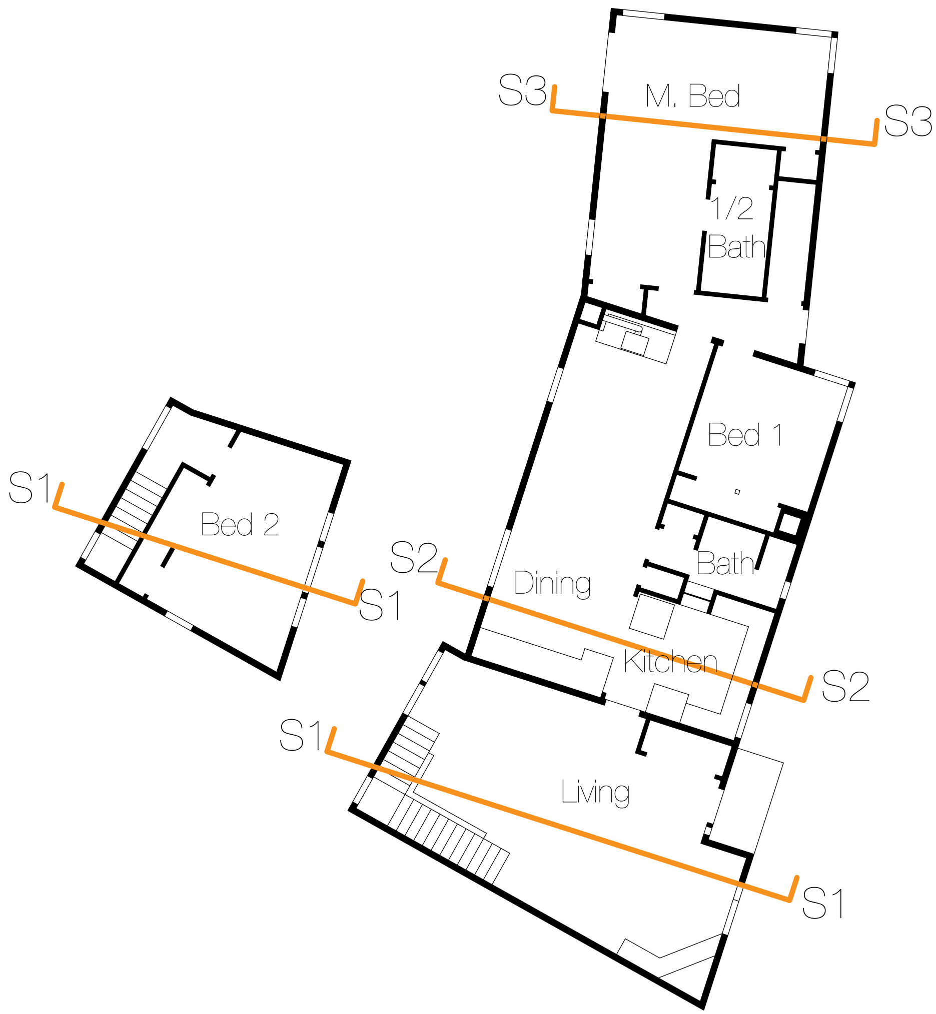
Scale: 1"=32'-0"

SA.10

Heating Analysis

The Hughes Residence is a hodge-podge of construction techniques and technologies, beginning as a 1-br residence constructed in 1955, it was modified and enlarged over time. It is fairly airtight, and most windows are double glazed. The newest portions of the dwelling, Zone 4 (PS.5), feature some of the highest R values because of a false ceiling with an enclosed insulated airspace.

The basement crawl space and the full height basement are conditioned so that the water pipes do not freeze and burst. This is especially important for the laundry room whose water pipes run directly along the concrete walls. The concrete walls conduct much of the cold from the outside earth and are uninsulated. The crawl space becomes quite warm because this is where the oil fueled boiler is located.



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Existing Building Plan

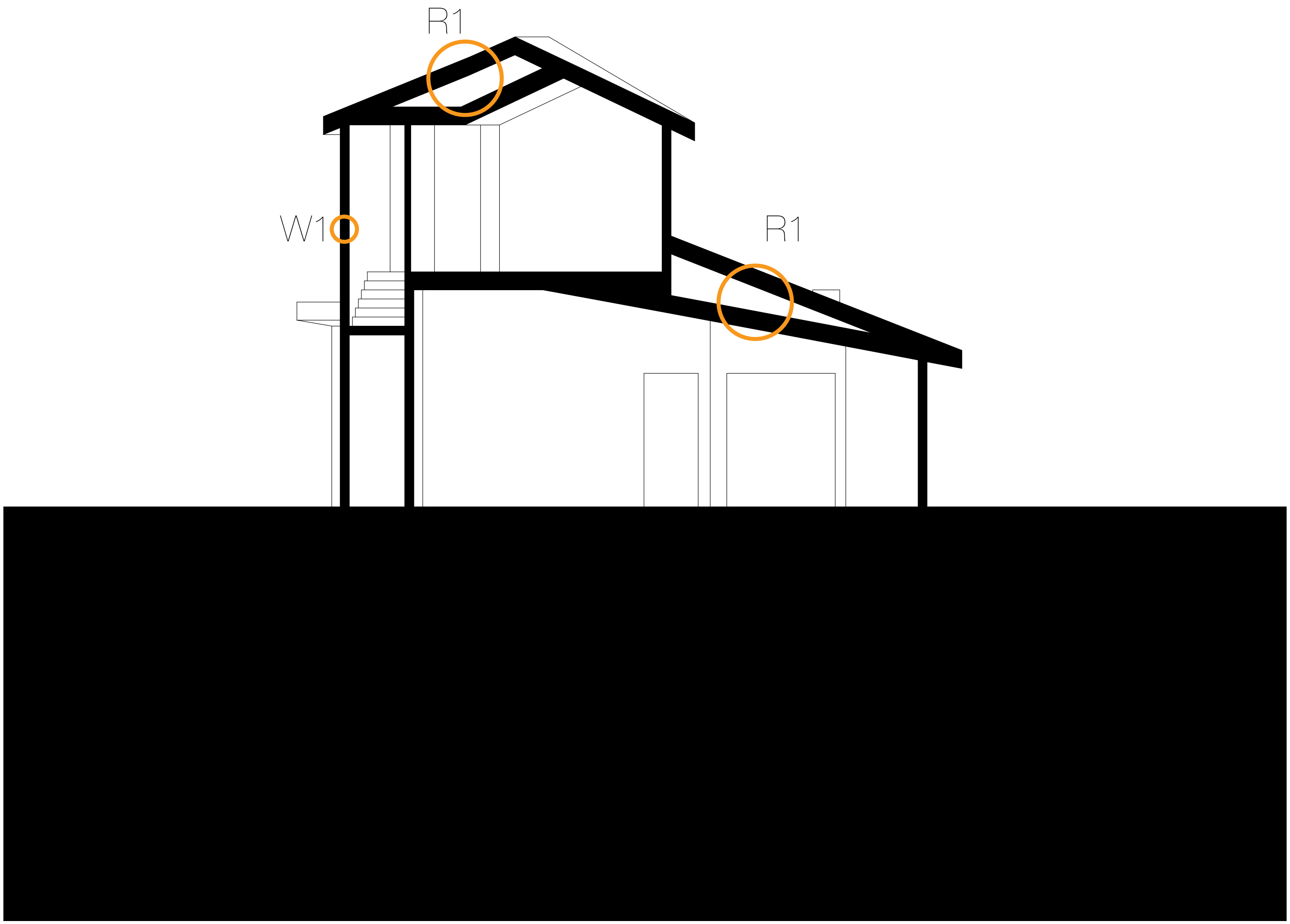
Each zone of the house is unique in the way the spaces are arranged and the way they are insulated. I am able to analyze each of the 4 zones by taking 3 lateral sections.

Zones definitions can be found on sheet PS.5. Zones are numbered in order of construction and correspond to separate heating zones.

All spaces shown are heated.

Scale: 1"=16'-0"

HA.2



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Existing Building Section S1

Section through zones 3 (lower) and 4 (upper). Concrete slab foundation.

Zones definitions can be found on sheet PS.5. Zones are numbered in order of construction and correspond to separate heating zones.

All spaces shown are heated.

Scale: 1"=8'-0"

HA.3

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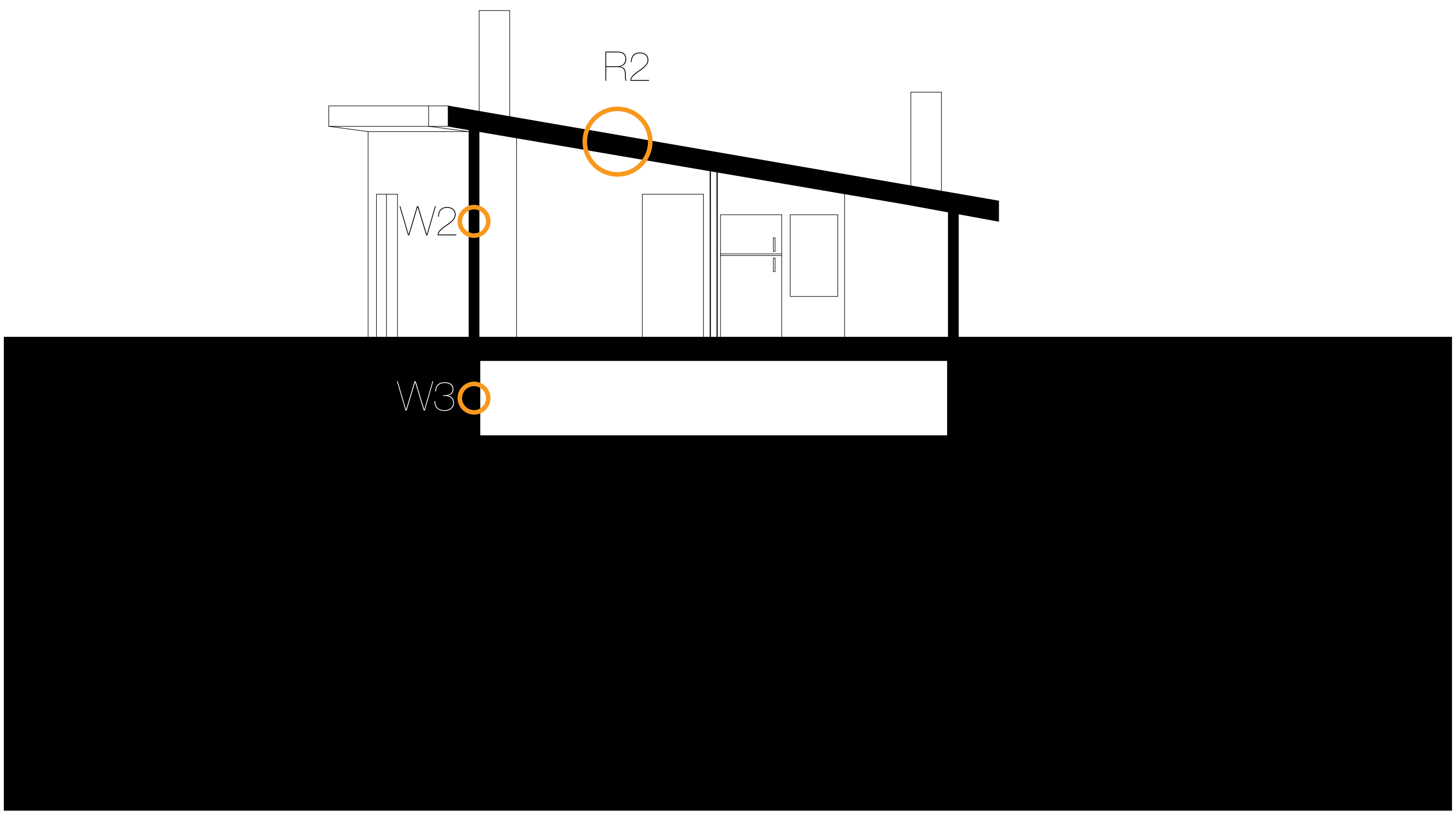
Existing Building Section S2

Section through Zone 1. Crawl-space beneath.

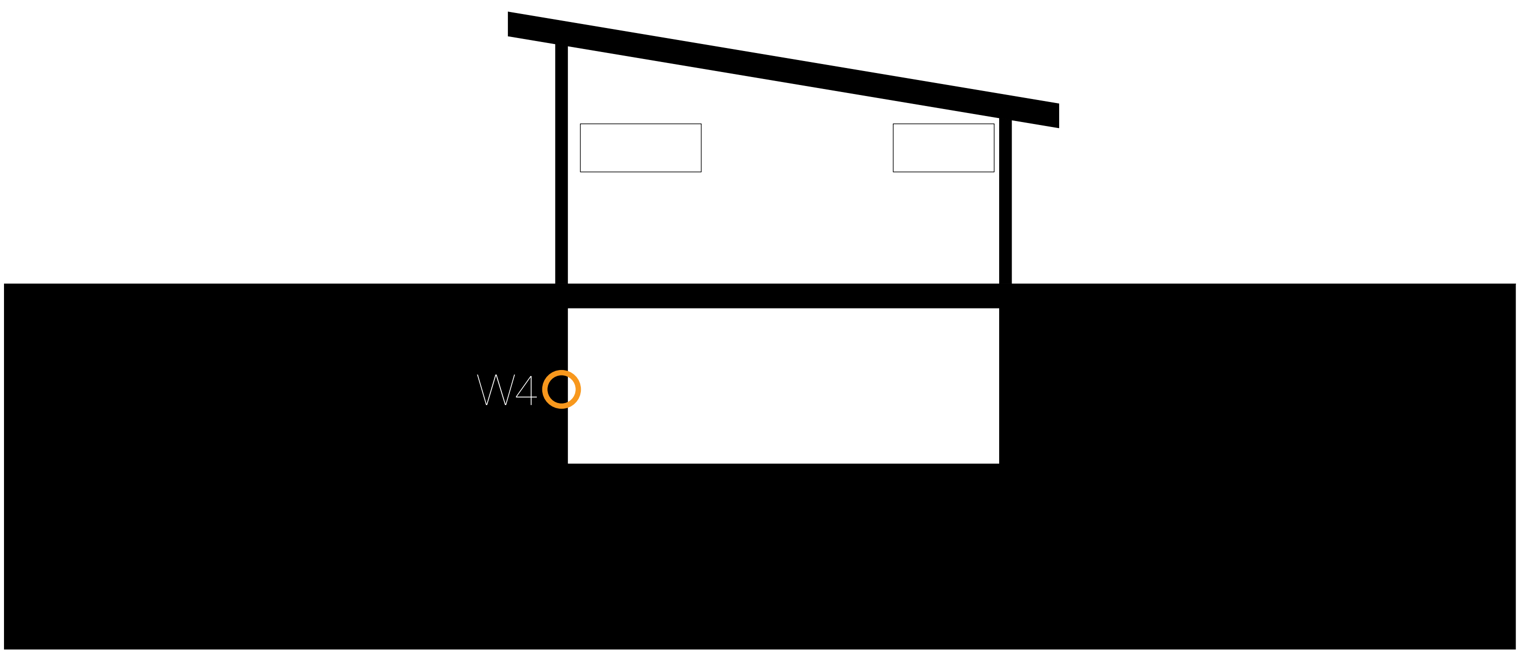
Zones definitions can be found on sheet PS.5. Zones are numbered in order of construction and correspond to separate heating zones.

All spaces shown are heated.



Scale: 1"=8'-0"

HA.4



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Existing Building Section S3

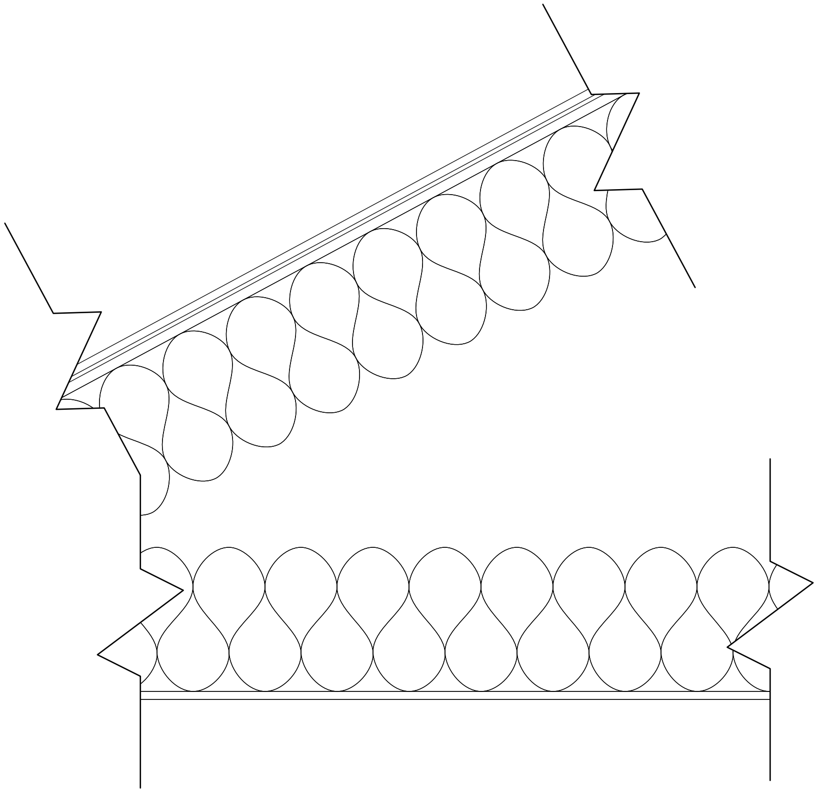
Section through Zone 2. Full basement beneath.

Zones definitions can be found on sheet PS.5. Zones are numbered in order of construction and correspond to separate heating zones.

All spaces shown are heated.

Scale: 1"=8'-0"

HA.5

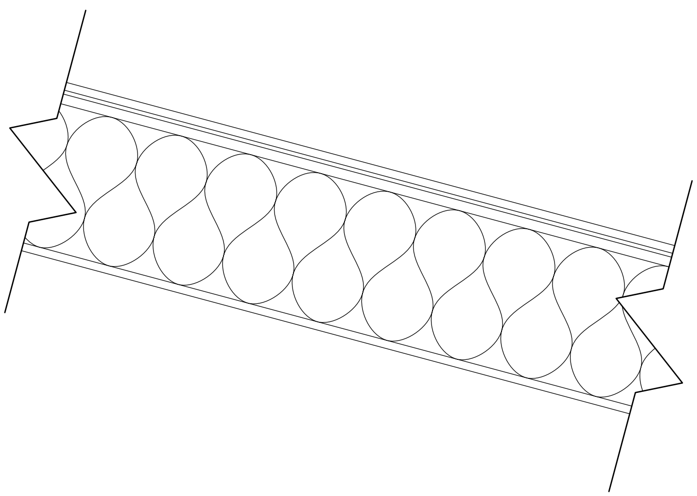


Section R1

Section R1	R Value
Asphalt Shingles	0.44
Tyvek	
5/8" Exterior Grade Plywood Sheathing	0.59
9" Fiberglass Roll Insulation	30
Average 24" air space	1.41
9" Fiberglass Roll Insulation	30
1/2" Gypsum Board	0.32
TOTAL	62.76

R= 62.76
U= 1/62.76 = 0.02 BTU/hr ºF ft^2

Total Area of R1: 570 sf



Section R2

Section R2	R Value
Asphalt Roll Roofing	0.15
Grace © Ice and Water Sheild Underlayment	
5/8" Exterior Grade Plywood Sheathing	0.59
6-1/4" Fiberglass Roll Insulation	19
1/2" Gypsum Board	0.32
TOTAL	20.06

R= 20.06
U= 1/20.06 = 0.05 BTU/hr ºF ft^2

Total Area of R2: 1780 sf

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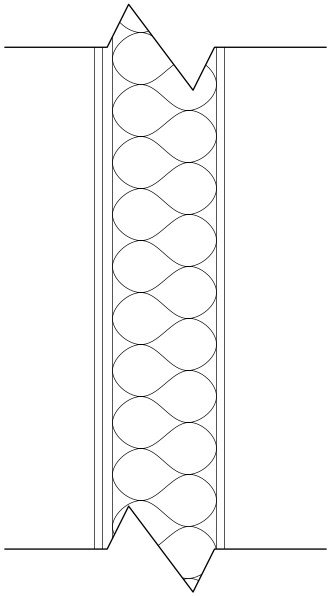
Roof Details R1 & R2

Scale: 1"=1'-0"

HA.6

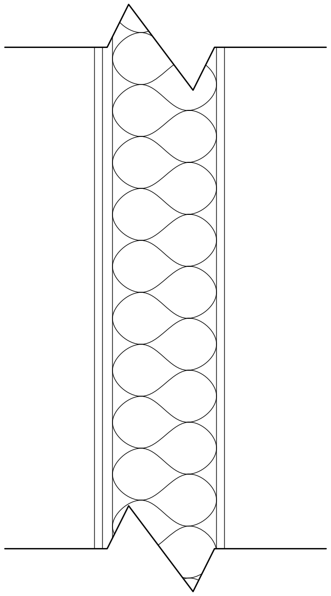


Section W1

	R Value
1/2" Airspace within siding	0.5
5/8" Exterior Grade Plywood Sheathing	0.59
6-1/4" Fiberglass Roll Insulation	19
1/2" Gypsum Board	0.32
TOTAL	20.41

R= 20.41
U= 1/20.41 = 0.05 BTU/hr ºF ft^2

Total Area of W1: 1248 sf



Section W2

	R Value
1/2" Airspace within siding	0.5
5/8" Exterior Grade Plywood Sheathing	0.59
3-1/2" Fiberglass Roll Insulation	13
1/2" Gypsum Board	0.32
TOTAL	14.41

R= 14.41
U= 1/14.41 = 0.07 BTU/hr ºF ft^2

Total Area of W2: 1246 sf

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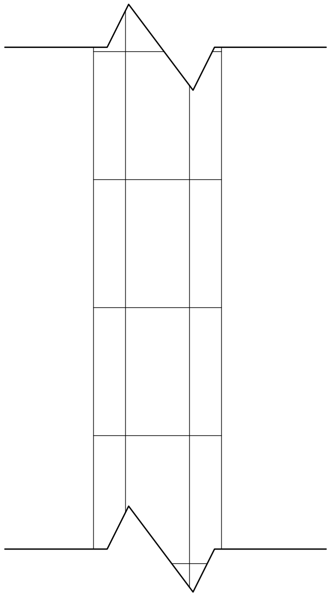
Wall Details W1 & W2

Scale: 1"=1'-0"



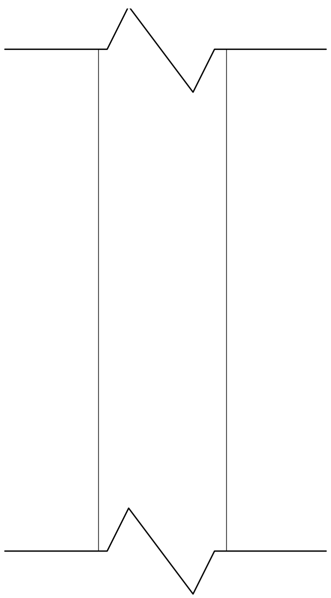
Section W3

	R Value
8" 3 cell Concrete Cinder Block	2.5
TOTAL	2.5

R= 2.5

U= 1/2.5 = 0.4 BTU/hr ºF ft^2

Total Area of W1: 560 sf



Section W4

	R Value
8" Poured Structural Concrete	3.5
TOTAL	3.5

R= 3.5

U= 1/3.5 = 0.28 BTU/hr ºF ft^2

Total Area of W1: 630 sf

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Wall Details W3 & W4

Scale: 1"=1'-0"

HA.8

	Detail #	U-value BTU/hr°Fft^2	Total Area ft^2	Heat Loss Coefficient UA=BTU/hr°F
Roofs	R1	0.02	570	11.4
	R2	0.05	1780	89
Walls	W1	0.05	1248	62.4
	W2	0.07	1246	87.22
	W3	0.4	560	224
	W4	0.28	630	176.4
Windows	Single Glazed	1	35	35
	Double Glazed	0.5	140	70
Infiltration	0.8	0.018	18810	270.864
Total Heat Loss Coefficient (total UA)				1026.284

Heat Loss Source	UA Heat Loss	%
Roofs	100.4	9.78%
Walls	550.02	54%
Windows	105	10%
Infiltration	270.864	26%

Peak Heat Loss (BTUh) =	Total UA	x T (design indoor °F - design outdoor °F)
66708.46	1026.284	65

Annual Heat Loss (MMBTU) =	Total UA	x 24 hours	x annual degree days
111380550	1026.284	24	4522

Building Energy Performance kWh/m^2 =			
Annual Loss (MMBTU) /	Sq. Ft. Heated =	BEPS (BTU/sf)	x .00315 US --> Metric
111380550	2090	53292.12916	0.00315
		167.8702069	kWh/m^2

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Building Heat Loss Coefficients

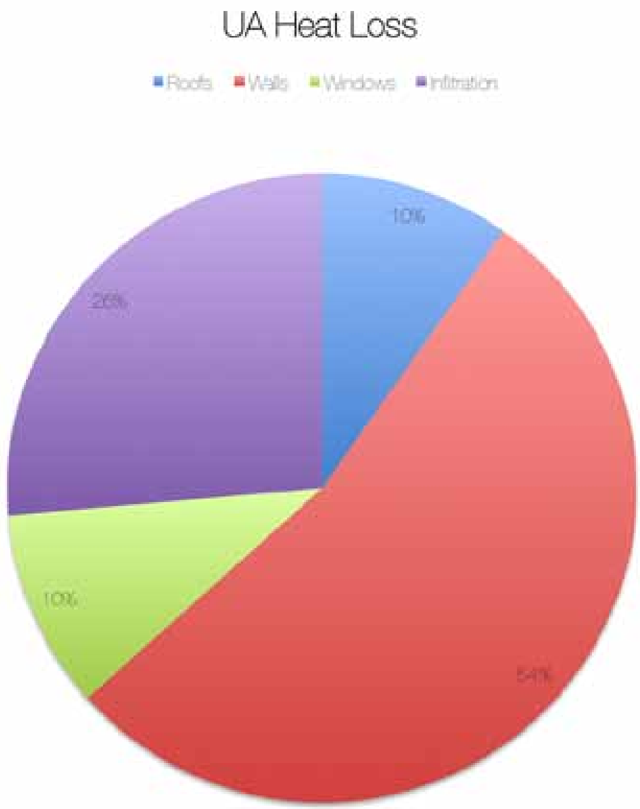
Building Energy Performance is measured in kWh/m^2. The target value for newly constructed energy efficient homes is 50 kWh/m^2 and below. The value for this house is 168 kWh/m^2 which puts it in the category of high energy consumption buildings.

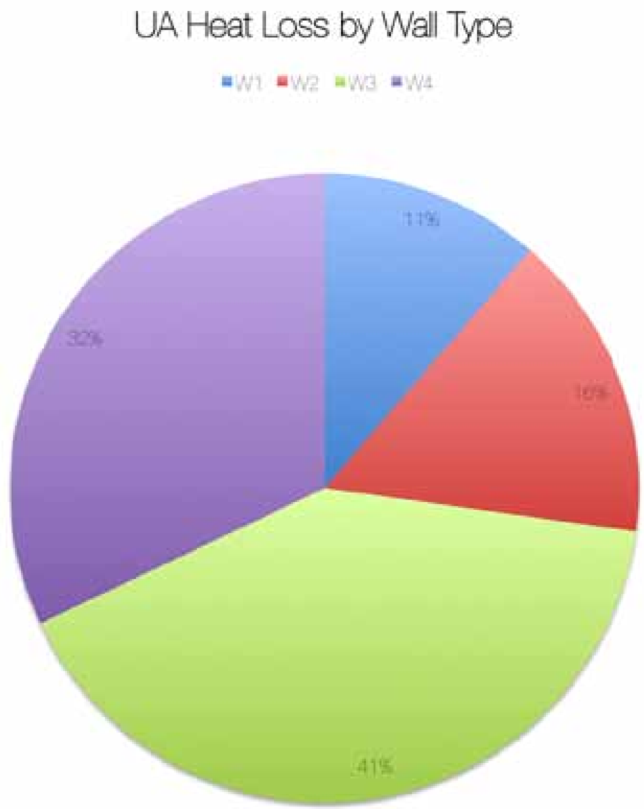
This is largely due to heat lost through foundation walls (W3 + W4).

NOTE: Infiltration is calculated as (Number of Air Changes) x (the Heat Capacity of Air .018 BTU ft^3 °F) x (Heated Volume of the Building)

Scale: N/A

HA.9





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Elijah Hughes

Hughes Residence
272 Webbs Mills Road
Raymond, Maine 04071

UA Heat Loss Comparison

More than 54% of all heat loss is through underinsulated walls, and 73% of that is through the bare concrete foundation walls (W3+W4).

Scale: N/A

HA.10

Energy Use Analysis

Heating is the largest energy expense but that does not mean there are other areas of energy use that should also be analyzed. Appliances, lighting, water use, and cars also factor into the overall energy use of a household.

Scale: N/A

Heating Load

Building Load Coefficient (BLC) = UA x 24   UA = 1026.284   BLC = 24630.816

Heating system efficiency is the average of the furnace and the boiler. The boiler heats twice as much as the furnace so it's efficiency was weighted more. The boiler is newer and is more efficient but is not used to full capacity.
Boiler = 80%. Furnace = 68%. System Efficiency = 76%.

Price (oil): $8.97/MMBTU
Cost per year: $1,314.58

BTU/ft^2/year = MMBTU / ft^2 BTU/ft^2/year = 53,292

	BLC = UA x 24		Mo. HDD		Heating Load BTU x 10^6		System Efficiency		Heating System Demand BTU x 10^6		Cost / MMBTU		Total Heating Cost
Jan	24630.816	x	787	=	19.384	/	0.76	=	25.506	x	$8.97	=	$228.79
Feb	24630.816	x	599	=	14.754	/	0.76	=	19.413	x	$8.97	=	$174.13
Mar	24630.816	x	549	=	13.522	/	0.76	=	17.793	x	$8.97	=	$159.60
Apr	24630.816	x	420	=	10.345	/	0.76	=	13.612	x	$8.97	=	$122.10
May	24630.816	x	249	=	6.133	/	0.76	=	8.070	x	$8.97	=	$72.39
Jun	24630.816	x	91	=	2.241	/	0.76	=	2.949	x	$8.97	=	$26.45
Jul	24630.816	x	28	=	0.690	/	0.76	=	0.907	x	$8.97	=	$8.14
Aug	24630.816	x	35	=	0.862	/	0.76	=	1.134	x	$8.97	=	$10.17
Sep	24630.816	x	102	=	2.512	/	0.76	=	3.306	x	$8.97	=	$29.65
Oct	24630.816	x	326	=	8.030	/	0.76	=	10.565	x	$8.97	=	$94.77
Nov	24630.816	x	567	=	13.966	/	0.76	=	18.376	x	$8.97	=	$164.83
Dec	24630.816	x	769	=	18.941	/	0.76	=	24.922	x	$8.97	=	$223.55
TOTALS			4522		111.381				146.553				$1,314.58

Heating usage and cost

NOTE: There is no need for active cooling systems in this climate. A cooling load chart was omitted.

Scale: N/A

Lighting Load

Total kWh/mo: 192.75
Central Maine Power Electricty Price: $0.0853 / kWh
Cost per month: $16.44
Cost per year: $197.30

	Quantity		Average Lamp Wattage (w)		Average Hours on per Month (h/mo)		Total (kWh/mo)
Incandescent	15	x	65	x	120	=	117
Fluroescent	20	x	20	x	180	=	72
Halogen	1	x	25	x	150	=	3.75
LED	0	x	12	x	0	=	0
							192.75

Appliance Load

Total kWh/mo: 322.824
Central Maine Power Electricty Price: $0.0853 / kWh
Cost per month: $27.54
Cost per year: $330.48

	Average wattage (w)		Average hours in use (hrs/mo)		Total kWh/mo
Refridgerator/Freezer	500	x	180	=	90
Dryer	700	x	12	=	8.4
Washer	500	x	10	=	5
Oven/Stove	2000	x	60	=	120
Computer	300	x	200	=	60
Microwave Oven	1000	x	2	=	2
Toaster Oven	1200	x	1	=	1.2
DVD	14	x	16	=	0.224
CRT Television 27"	300	x	120	=	36
					322.824

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Lighting and Appliance Loads

Lighting usage and cost
Appliance usage and cost

Scale: N/A

Domestic Hot Water Load

Gallons of hot water used: 2,200 g/mo
Domestic Hot Water is heated by the oil fueled boiler, which has an efficiency of 80%.
MMBTU/mo = 2,200 x 0.001 = 2.2 MMBTU/mo
2.2 MMBTU/mo / .8 efficiency = 2.75
Price (oil): $8.97/MMBTU

Cost per month: $24.67
Cost per year: $296.04

Vehicle Load

1991 Chevy Caprice Classic	8,000 miles/year/15mpg = 533.33 gallons x 0.125 MMBTU/gallon = 66.67 MMBTU
2003 Dodge Grand Caravan	12000 miles/year/20mpg = 600.00 gallons x 0.125 MMBTU/gallon = 75 MMBTU
2009 Dodge Charger	18000 miles/year/19mpg = 947.37 gallons x 0.125 MMBTU/gallon = 118.42 MMBTU

Total: 2080.7 galllons/year Average Price: $3.55/gallon
Total: 260.09 MMBTU/year Average Price: $28.40/MMBTU

Cost per month: $615.55
Cost per year: $7,386.57

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DHW and Vehicle Loads

Domestic Hot Water usage and cost
Vehicle usage and cost

Price per MMBTU is highest with vehicles because they are the least efficient machine used in everyday life.

Scale: N/A

Oil Cost

Estimated cost: $1,610.62
Actual 2010 cost: $1,523.92

Error: 5.69%

	Heating Cost	DHW Cost	Estimated Total Oil Cost
Jan	$228.79	$24.67	$253.46
Feb	$174.13	$24.67	$198.80
Mar	$159.60	$24.67	$184.27
Apr	$122.10	$24.67	$146.77
May	$72.39	$24.67	$97.06
Jun	$26.45	$24.67	$51.12
Jul	$8.14	$24.67	$32.81
Aug	$10.17	$24.67	$34.84
Sep	$29.65	$24.67	$54.32
Oct	$94.77	$24.67	$119.44
Nov	$164.83	$24.67	$189.50
Dec	$223.55	$24.67	$248.22
TOTAL	$1,314.58	$296.04	$1,610.62

Electricity

Estimated cost: $527.78
Actual 2010 cost: $572.63

Error: 7.83%

	Lighting Cost	Appliance Cost	Estimated Total Electric Cost
Jan	$16.44	$27.54	$43.98
Feb	$16.44	$27.54	$43.98
Mar	$16.44	$27.54	$43.98
Apr	$16.44	$27.54	$43.98
May	$16.44	$27.54	$43.98
Jun	$16.44	$27.54	$43.98
Jul	$16.44	$27.54	$43.98
Aug	$16.44	$27.54	$43.98
Sep	$16.44	$27.54	$43.98
Oct	$16.44	$27.54	$43.98
Nov	$16.44	$27.54	$43.98
Dec	$16.44	$27.54	$43.98
TOTAL	$197.30	$330.48	$527.78

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Annual Energy Costs

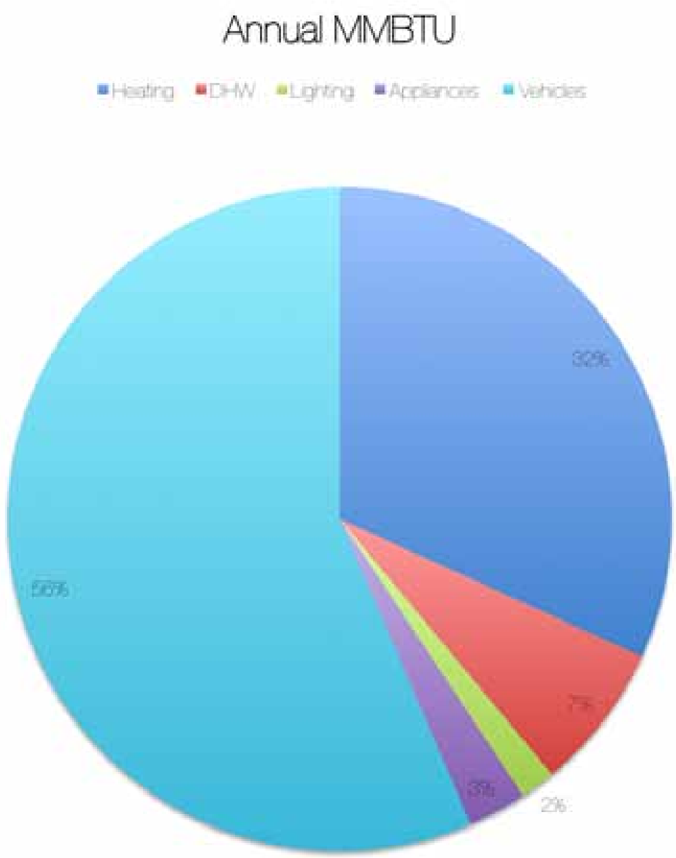
Estimated oil cost and actual cost
Estimated electricity cost and actual cost

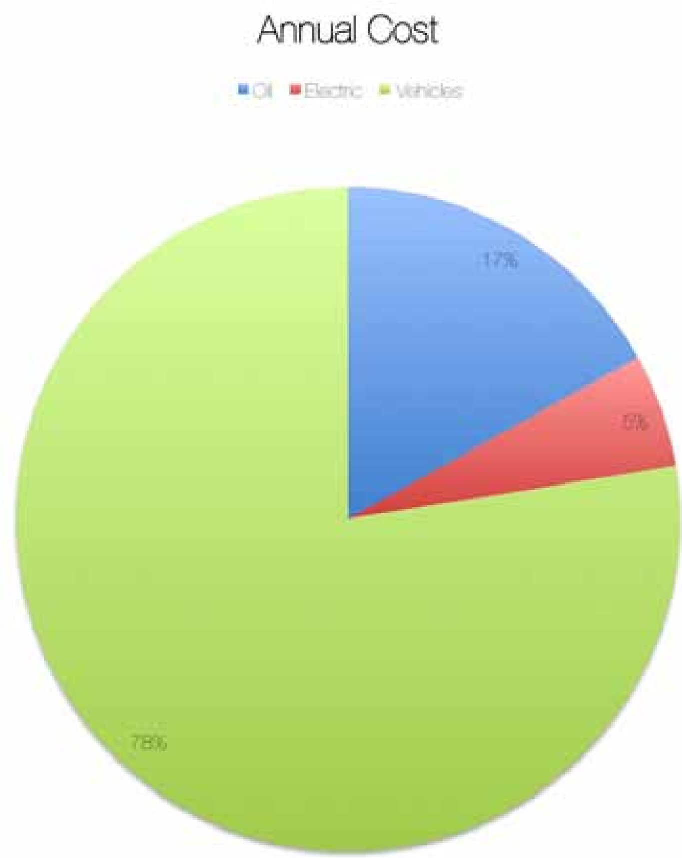
Scale: N/A

EA.5

	Heating	DHW	Lighting	Appliances	Vehicles	TOTAL
Annual MMBTU	146.55336	33	7.891	13.218	260.09	460.75236
Percentage of Total Energy Usage	32%	7%	2%	3%	56%	100%

	Oil	Electric	Vehicles	TOTAL
Annual Cost	$1,610.62	$527.78	$7,386.57	$9,524.97
Percentage of Total Energy Cost	17%	6%	78%	100%





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Comparison of Energy Costs

Comparison of annual energy usage in MMBTU
Comparison of annual energy cost in $

Scale: N/A

EA.6

Recommendations

With some adjustments, this house can be made much more efficient. All of these recommendations pay for themselves as energy = money. Energy saved is money saved. Some turn around in a few months while others may take years.

Scale: N/A

Basement Insulation

Owens Corning Foamular F-150 2 in. x 4ft. x 8 ft.
Scored Squared Edge Foam

This rigid foam insulation will add an R-value of 10 to the cold foundation walls. It can be attached by nailing it to the concrete using a high powered pneumatic nail gun. It will retail 90% of its R-value over the long term.

The basement would remain a conditioned space to prevent pipes from freezing.

$22.96 per sheet
40 Sheets needed

40 Sheets	$918.40
Nails	$0.00
Nail Gun	$0.00
Labor	$0.00
TOTAL	$918.40

Former UA	=	1026.284
Former Heating Cost	=	$1314.58
New UA	=	714.784
New Heating Cost	=	$915.58
Annual Savings	=	$399.00/yr

This retrofit will pay back in 2.3 years

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Basement Insulation

Scale: N/A

R.2

Furnace Elimination

Currently Zone 2 is heated by a forced hot air furnace. This could be heated with radiant hot water provided by the existing boiler. This would raise the overall percentage efficiency of the system.

This is labor intensive. The owner of the home is well equipped to perform this transformation and is already working on it. This was already done to the rest of the household.

Slant Fin 5 ft. 893-Watt Hydronic Baseboard Heater
$46.48
5 units needed

Wieland Copper Tubing 3/4 in. x 10 ft.
$20.44
4 units needed

Taco 007-F5 Cast Iron Circulator Pump, 1/25 HP
$80.45
1 needed

Baseboard x5	$232.40
Copper Tubing x4	$81.76
Circulator Pump x1	$80.45
Copper Fittings	$0.00
Labor	$0.00
TOTAL	$394.61

Former Percentage Efficiency	76%
Former Heating Cost	$915.58
New Percentage Efficiency	80%
New Heating Cost	$869.80
Annual Savings	$55.78

This retrofit will pay back in 7.1 years

Note: May payback sooner because there will no longer be heating redundancy.

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Furnace Elimination

Scale: N/A

R.3

Door Replacement

The sliding glass door in the master bedroom is highly inefficient and is drafty. It is single pane glass with an aluminum frame. While energy savings from this are relatively small, there will be a great improvement in the comfort of the Master Bedroom. It will also add aesthetic value.

Andersen 100 Series Gliding Door Low-E
$840.00
1 Unit Needed

Door	$840.00
Labor	$0.00
TOTAL	$840.00
Former U Value	1
Former Heating Cost	$859.80
New U Value	0.29
New Heating Cost	$839.56
Annual Savings	$20.24

This retrofit will pay back in 41.5 years

Bulb Replacement

There are 15 incandescent light bulbs in the house. These should be replaced with highly efficient Compact Fluorescent bulbs. Advances in CFL technology allow them to render the same color temperature ranges as incandescent bulbs.

EcoSmart 14-Watt (60W) Bright White CFL Light Bulb (2-Pack)

	$4.62
	8 packs needed
Bulbs	$840.00
Labor	$0.00
TOTAL	$36.96
Former Lighting Load	192.75 kWh/mo
Former Lighting Cost	$197.30/yr
New Lighting Load	129.75 kWh/mo
New Lighting Cost	$132.81/yr
Annual Savings	$64.49

This retrofit will pay back in 7 months

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Bulb Replacement

Scale: N/A

R.5

Rezone Heated areas of the home

This is a behavioral. If occupants spend more time in living spaces than bedroom spaces, zones 2 and 4 can be turned to a reduced temperature. This gives us a new base temperature for the house so that we can calculate the number of heating degree days. The new set point in these zones would be 55ºF.

TOTAL Cost	$0.00
Total area of the house	2090sf
Area of reduced temperature	765sf
Remaining area	1325sf

$$\frac{1325\text{sf} \times 65^{\circ}\text{F} + 765 \times 55^{\circ}\text{F}}{2090\text{sf}}$$

New Base Temperature	61.3ºF
Former Heating Degree Days	4522
Former Heating Cost	$839.56
New Heating Degree Days	4264.6
New Heating Cost	$791.77
Annual Savings	$47.79

This retrofit will pay back immediately

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Rezone Heated areas of the home

Scale: N/A

Setback Thermostat

A programmable setback thermostat makes it easy to keep spaces cooler when they are not in use. This gives us a new base temperature for the house so that we can calculate the number of heating degree days. The new set point in these zones would be 55ºF.

Honeywell 1-Week Programmable Thermostat
$19.88
4 units needed

Thermostat	$79.52
Labor	$0.00
TOTAL Cost	$79.52

$$\frac{1325sf \times 65ºF \times 12 + 1325sf \times 55ºF \times 12 + 765 \times 55ºF \times 24}{2090sf}$$

New Base Temperature	58.2ºF
Former Heating Degree Days	4264.6
Former Heating Cost	$791.77
New Heating Degree Days	4048.9
New Heating Cost	$751.72
Annual Savings	$40.05

This retrofit will pay back in 2 years

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Setback Thermostat

Scale: N/A

R.7

Caulking and Weatherstripping

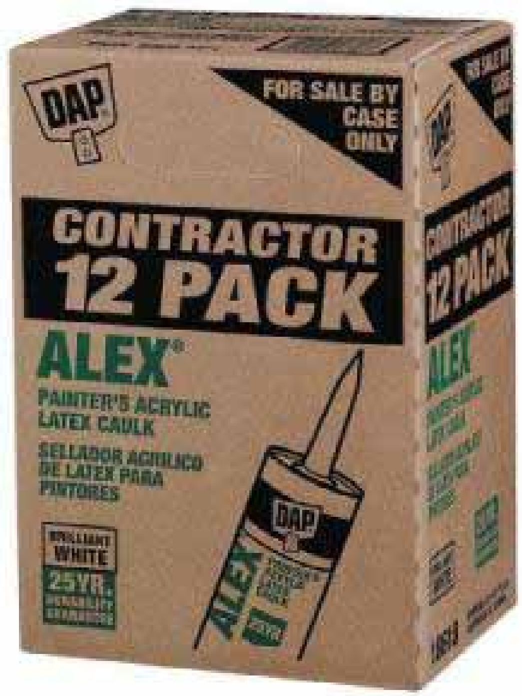
Sealing around openings can reduce infiltration by 20%. It is a cheap and easy thing to do. Caulk is to be used around non-operable openings while weatherstripping can be used around windows and doors.

DAP ALEX 10.1 oz. Painter's All-Purpose Acrylic Latex Caulk (12-Pack)
$16.98
1 pack needed

MD Building Products 1/4 in. x 17 ft. Low-Density Foam Weatherstrip Tape
$2.48
10 rolls needed

Caulk	$16.98
Weatherstripping	$24.80
Labor	$0.00
TOTAL Cost	$41.78
Infiltration loss reduction	20%
Former infiltration loss	270.864 MMBTU
Former Heating Cost	$751.72
New infiltration loss	216.691
New Heating Cost	$692.70
Annual MMBTU Savings	54.173
Annual Savings	$59.02

This retrofit will pay back in 8 months



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Caulking and Weatherstripping

Scale: N/A

R.8

TV Replacement

Not only are Cathode Ray Tubes bulky, they are also highly innefficient. A 27" CRT television set uses 300 watts when it is turned on. Currently the most efficient television sets are LED flat screens (not to be confused with LCD or Plasma screens). An LED screen of the same size uses less than half of the electricity. The newer screens also produce a significantly better picture.

It will take longer to pay off for the Hughes Family because they do not watch a huge amount of television.

Sharp - 26" Class / LED / 1080p / 60Hz / HDTV
Model: LC-26SV490U

	$269.99
Television	$269.99
Labor	$0.00
TOTAL Cost	$269.99
Former Television Wattage	300
Former Appliances Electric Cost	$330.48
New Television Wattage	58
New Appliances Electric Cost	$300.72
Annual Savings	$29.76

This retrofit will pay back in 9 years

Payoff

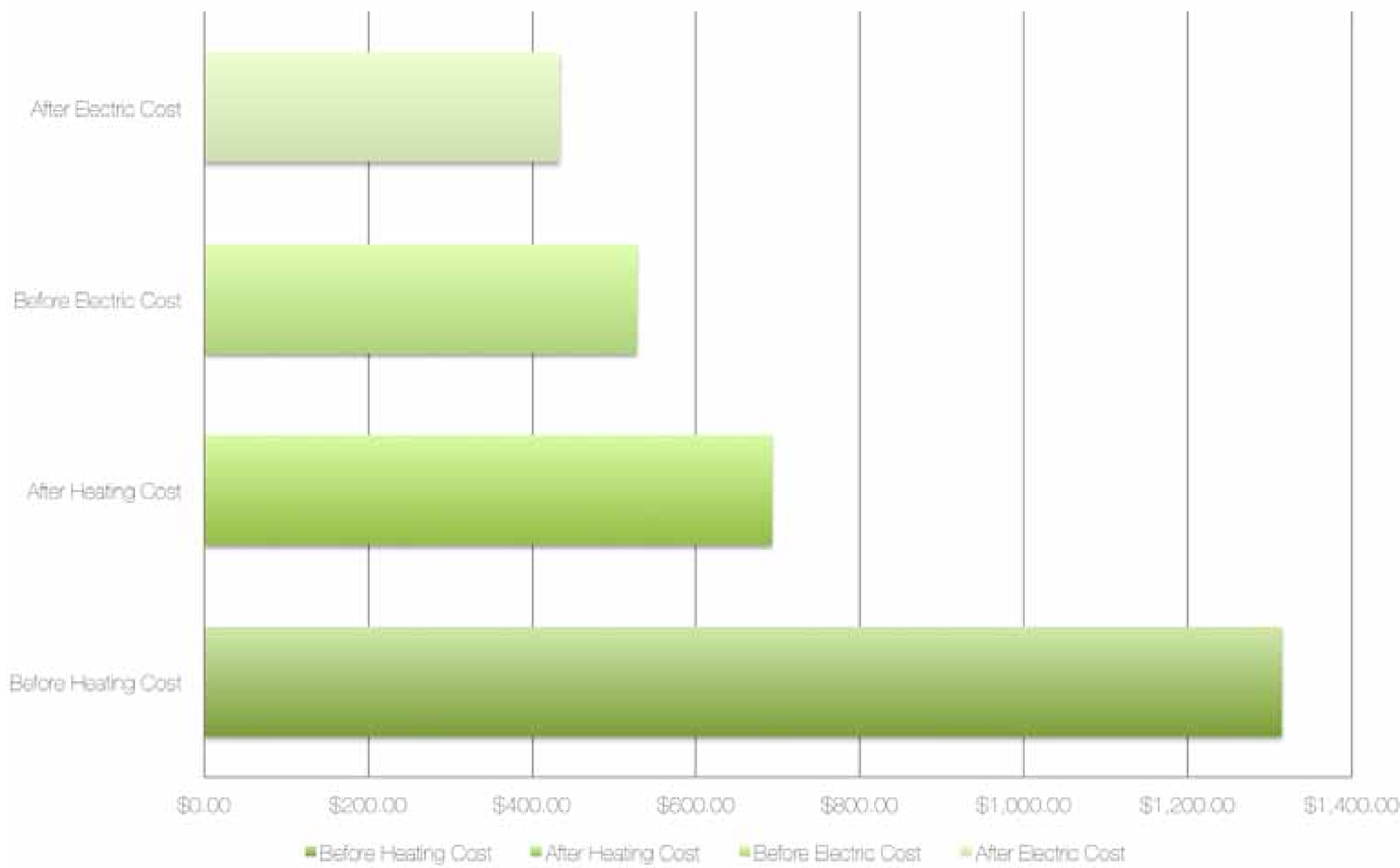
Cost of Heating before retrofit	$1314.58
Cost of Heating after retrofit	$692.70
Annual Heating Savings	$621.88
Total Cost of Heating retrofits	$2274.31

Heating Retrofits will pay back in 3.7 years

Cost of Electric before retrofit	$527.78
Cost of Electric after retrofit	$433.53
Annual Electric Savings	$94.25
Total Cost of Electric retrofits	$305.95

Electric Retrofits will pay back in 3.2 years

Cost Comparison



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Cost Comparison

Scale: N/A

R.11

Passive Solar Strategies

There are ways to get more out of the sun's energy. Currently there is only one south facing window on the Hughes Residence. These calculations will find the ideal glazed surface area for the south face of the house.

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Passive Solar Strategies

Scale: N/A

Sun Tempering Calculations

$[UA_H+U_GA_G+U_{SW}(A_{SF}-A_G)](T_I-T_O)= I_SA_G$
$[607.96+0.5(A_G)+0.5(556-A_G)](40) = 179\ A_G$

A_G =198sf

UA_H	Retrofitted UA without south wall	607.96 BTU/hr°F
U_G	U Glass	0.5
U_{SW}	U South Wall	0.5
A_{SF}	Area of South Face	556sf
A_{SW}	Area of South Wall	548sf
A_{SG}	Area of Sotuh Glass	8sf
T_I	Temperature Indoor	65°F
T_O	Temperature Outdoor	25°F
I_s	Adjusted solar (ver.)	179 BTUh/ft^2/day

Area of South Glass Needed for Sun Tempering	198sf
Current Area of South Glass	8sf

The south face of the house should have more glazed openings to let in both natural light and solar heat. There are no privacy concerns as the trees are reasonably dense.

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Sun Tempering Calculations

Scale: N/A

Passive Solar Heating

Glazing Calculations

$LCR = 24UA_H/A_G$
$50 = 24(607.96)/A_G$
$A_G = 292$ sf

UA_H	Retrofitted UA without south wall	607.96 BTU/hr°F
LCR	Load to Collector Ratio	50
SSF	Solar Savings Fraction	28%

Area of South Glass Needed for Passive Solar Heating 292 sf

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Passive Solar Heating

Scale: N/A

Conclusion

The efficiency of the homes we live in is important to their affordability and comfort. This packet shows where the Hughes Residence exceeds (R1) and where it could use some help (W3+W4). With some easy retrofits and behavior changes it can be made a more affordable, valuable, and liveable household.

Scale: N/A