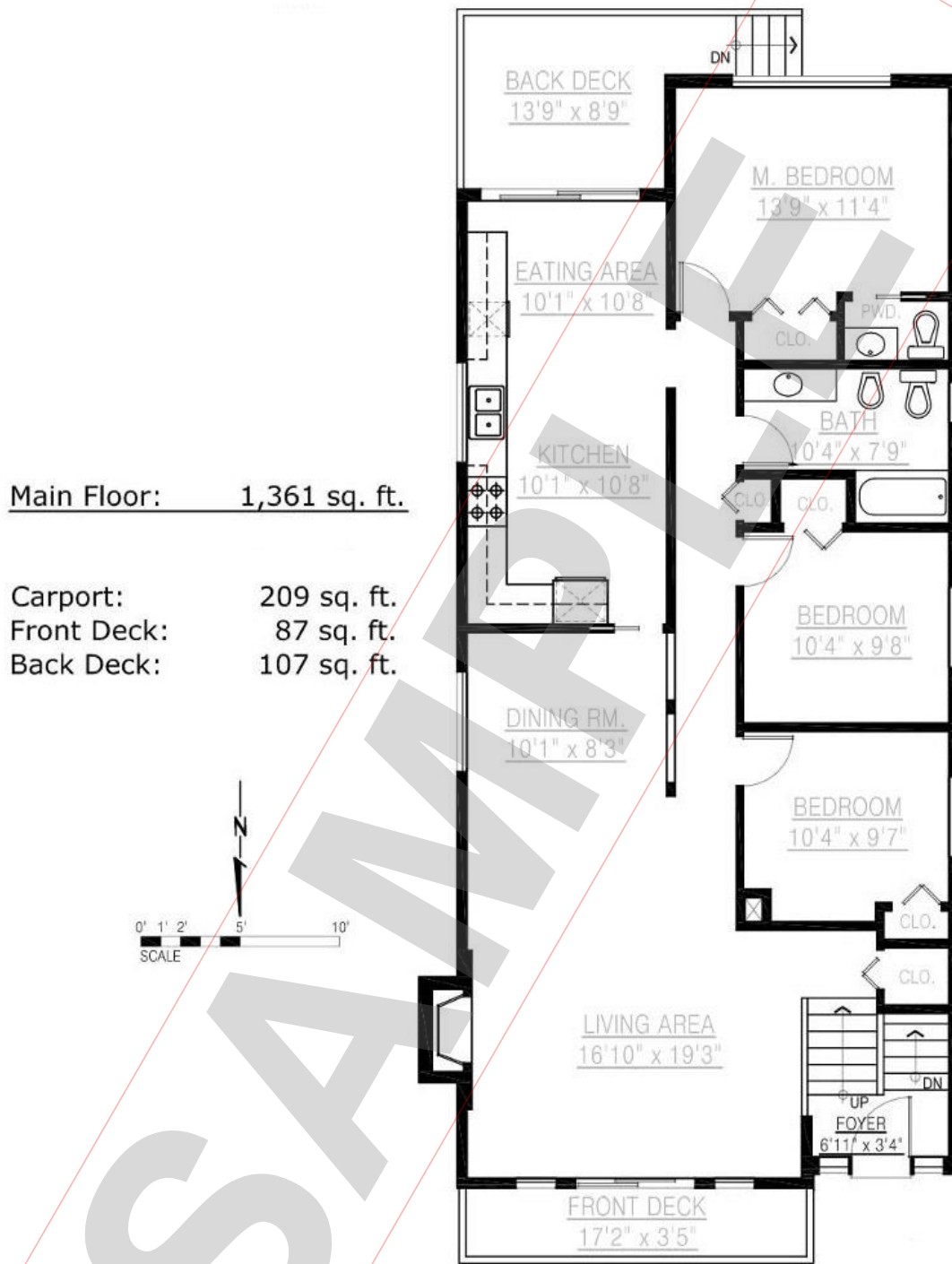


## 1.0 Summary

<b>House Type</b>	Wood frame house
<b>Year of Construction</b>	1979
<b>Floor Area</b>	Main Floor – 126.44 m <sup>2</sup>
<b>Location</b>	Kitsilano, Vancouver, B.C.
<b>Soil Type</b>	C
<b>Liquefaction Potential</b>	Very low
<b>Retrofit Priority Rank</b>	H1
<b>Seismic Deficiencies</b>	<ol style="list-style-type: none"><li>1. Weak LDRS in E-W direction, especially on the exterior</li><li>2. LDRS in N-S direction for the interior needs improvement</li><li>3. Roof diaphragm needs improvement</li></ol>
<b>Life-Safety Retrofit Features</b>	<ol style="list-style-type: none"><li>1. E-W exterior LDRS retrofit:<ul style="list-style-type: none"><li>• Tear down the front wall of the living room and remove the windows for new shear walls</li><li>• Redo foundation to accommodate the new shear walls</li></ul></li><li>2. E-W &amp; N-S interior LDRS retrofit:<ul style="list-style-type: none"><li>• Upgrade the walls in the two bedrooms with new studs, blocking, and sheathing</li></ul></li><li>3. Roof diaphragm retrofit:<ul style="list-style-type: none"><li>• Upgrade the ceiling/roof diaphragm with new blocking, plywood boards, and nailing/spike details</li><li>• Reinforce the connection between the new diaphragm and the walls</li></ul></li></ol>
<b>Retrofit Cost Estimates</b>	\$83,067 \$657 /m <sup>2</sup>



**MAIN FLOOR PLAN**  
FLOOR AREA: 1,361 sq.ft.

Figure 1: Architectural drawing of the house

## 2.0 Assessment Report

### 2.1 Vertical Load-Bearing Supports (VLS)

<b>VLS Type</b>	Timber platform construction
<b>VLS Design Drift Limit</b>	6.0%
<b>Supports Description</b>	The floor boards and joists, which act as a platform, are fastened over beams supporting the structure. The structural walls transfer the load from the roof and ceiling to the floor and the foundation.

### 2.2 Lateral Demand Resisting Systems (LDRSs)

#### 2.2.1 Main Level LDRS

Shaking Dir.	Location	Prototype No.	Description	Max. DDL	Capacity
N-S	Exterior	W-3	Gypsum wallboard	2.5%	10.07% Ws
	Interior	W-3	Gypsum wallboard	2.5%	2.94% Ws
E-W	Exterior	W-3	Gypsum wallboard	2.5%	1.44% Ws
	Interior	W-3	Gypsum wallboard	2.5%	3.88% Ws

- Comments**
- All walls are assumed to be built with 184 mm wide transverse boards sheathing
  - All walls are assumed to be properly connected to the foundation
  - Ws is the cumulative seismic weight of the structure (252.4 kN), which includes the weight of walls, roof, and snow

### 2.3 Diaphragms

#### 2.3.1 Roof Level Diaphragm

Shaking Direction	Prototype No.	Description	Span	Max. Movement	Capacity
N-S	D-3	Flexible diaphragm – horizontal boards	16.9 m	75 mm	7.81% Wd
E-W	D-3	Flexible diaphragm – horizontal boards	7.6 m	75 mm	3.51% Wd

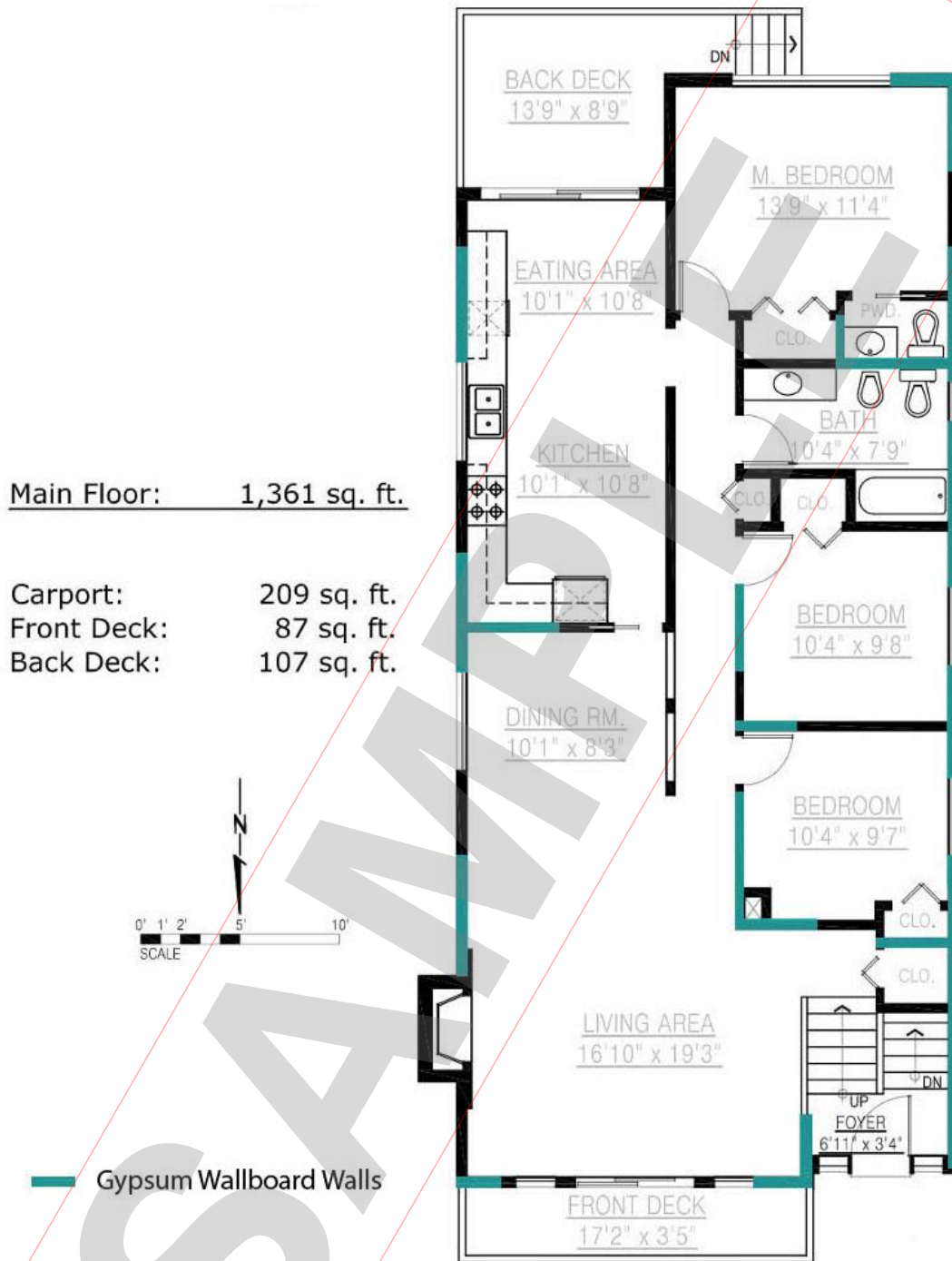
- Comments**
- Roof diaphragm is assumed to be built with 64 mm to 89 mm thick T&G decking (with no side spikes) spanning about 3 m between supporting beams
  - The maximum movement is governed by 2.5% drift limit of the 3 m wall height
  - Wd is the lumped seismic weight at the diaphragm's level (194.6 kN), which includes the weight of roof, snow, and half of the wall's

## 2.4 Risk Assessment Results

Element	Shaking Dir.	Loc.	Prototype No.	Capacity	PDE/PSE	RPR
Main Floor LDRS	N-S	Ext.	W-3	10.07% Ws	1.5%	L
		Int.	W-3	2.94% Ws	7.3%	H2
	E-W	Ext.	W-3	1.44% Ws	> 15.4%	H1
		Int.	W-3	3.88% Ws	4.5%	M
Roof-Level Diaphragm	N-S		D-3	7.81% Wd	2.1%	M
	E-W		D-3	3.51% Wd	6.5%	H3
<b>Maximum</b>					> 15.4%	H1

### Seismic Deficiencies

- Weak E-W LDRS, especially on the exterior of the house (highest priority)
- Interior N-S LDRS needs to be improved (second priority)
- Roof diaphragm needs to be improved (third priority in E-W direction and medium priority in N-S direction)
- Interior E-W LDRS needs to be improved (medium priority)



**MAIN FLOOR PLAN**  
FLOOR AREA: 1,361 sq.ft.

Figure 2: Locations of the structural walls

## 3.0 Retrofit Plan

### 3.1 Retrofit Concept

Considering that the governing PDE of the house is  $> 10\%$  (H-1 priority), a life-safety retrofit plan is highly recommended to lower the PDE to less than 2%. This plan addresses the seismic deficiencies mentioned in the previous section:

- E-W exterior LDRS retrofit:
  1. Tear down the front (north) wall of the living room and take out the two side windows.
  2. Redo foundation under the front (north) wall of the living room. This will require the removal of the carpeting in the living room and a portion of the floor to access the foundation.
  3. Rebuild the floor and reapply carpet.
  4. Rebuild the wall blocked plywood shear walls, redo electrical/mechanical, finish the interior and exterior of the new walls.
- E-W & N-S interior LDRS retrofit:
  1. Remove the wall sheathing of the two bedrooms (including the one in the closet) while still leaving the existing studs.
  2. Install the new studs and blocking while simultaneously removing the existing studs.
  3. Redo electrical/mechanical, install new sheathing, finish the interior walls.
- Roof diaphragm retrofit:
  1. Remove existing ceiling board, T & G decking, and insulation while trying to maintain as much electrical / mechanical / lighting / sprinklers / alarm in place.
  2. Install new plywood blocking to existing joists, install new plywood boards, return the insulation material and electrical / mechanical in place.
  3. Reinforce the connection between the diaphragm and the walls.
  4. Rebuild the ceiling board, finish the ceiling, return the lighting / sprinklers / alarm back in place.

No changes in the rest of the house.

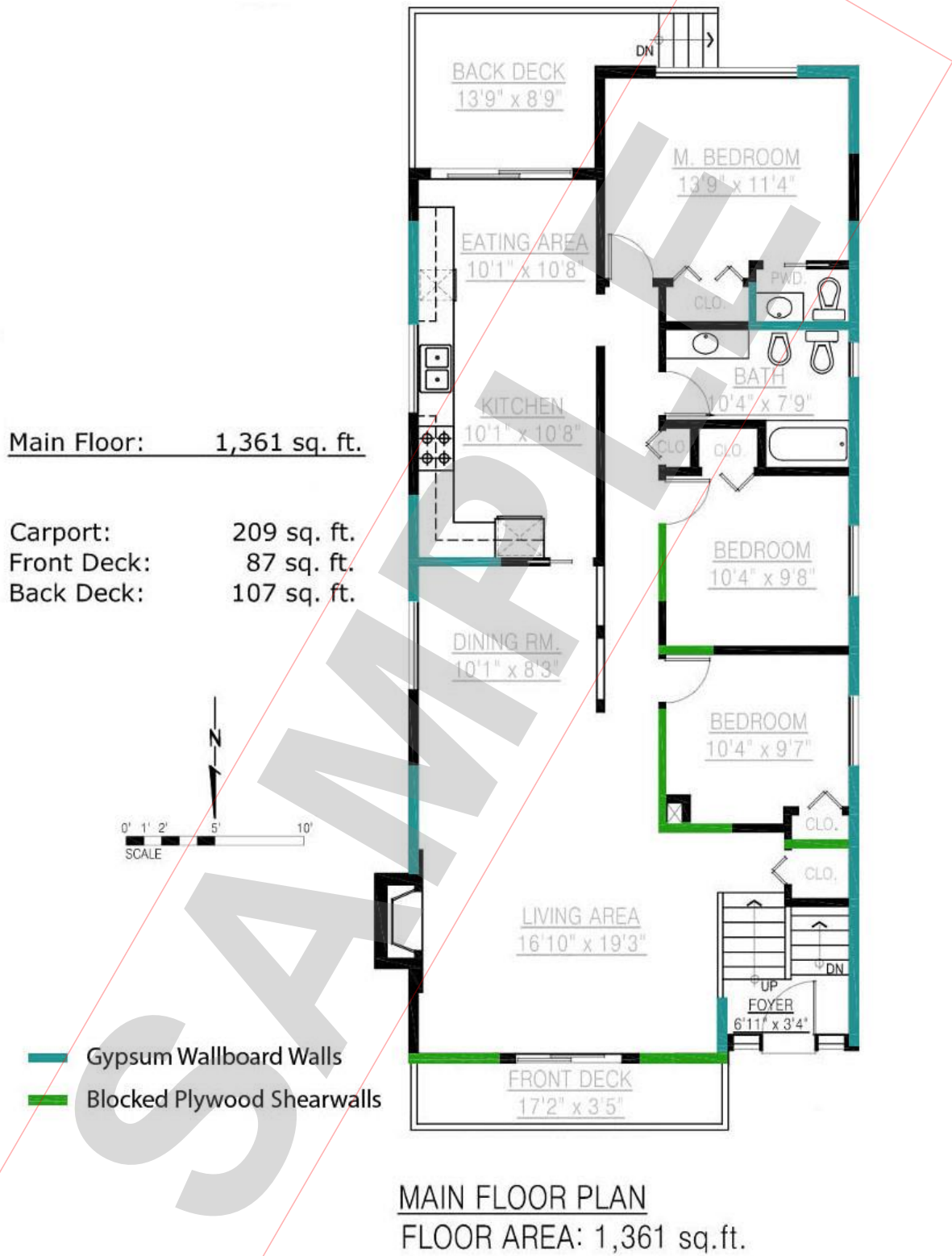


Figure 3: Locations of the retrofitted structural walls

### 3.2 Risk Assessment Results After Retrofit

Element	Shaking Dir.	Loc.	Prototype No.	Description	Capacity	PDE/PSE
Main Floor LDRS	N-S	Int.	W-1	Blocked plywood shear wall	14.83% Ws	1.2%
	E-W	Ext.	W-1	Blocked plywood shear wall	12.59% Ws	1.4%
		Int.	W-1	Blocked plywood shear wall	14.56% Ws	1.2%
Roof-Level Diaphragm	N-S		D-1	Blocked plywood diaphragm	45.15% Wd	0.4%
	E-W		D-1	Blocked plywood diaphragm	20.31% Wd	0.9%

SAMPLE



## 4.0 Retrofit Cost Estimate

### 4.1 Construction Cost Summary

Description	Amount (\$)
<b>A. Main Floor Life Safety Retrofit</b>	
1. New shallow foundations for new shear walls (living room)	8,759
2. New plywood shear walls (living room)	5,843
3. Interior walls upgrade to blocked plywood shear walls	13,574
4. Roof diaphragm upgrade to blocked plywood diaphragm	23,010
5. Interior wall top connections	4,600
6. Electrical & mechanical work	16,437
Sub-Total Construction Cost	72,223
Design Contingency	10,844
<b>Total Construction Cost</b>	<b>83,067</b>
Gross Floor Area	126.44 m <sup>2</sup>
Unit Cost	657 /m <sup>2</sup>

## 4.2 Construction Cost Breakdown

Description	Qty.	Unit	Rate (\$)	Amount (\$)
<b>A. Main Floor Life Safety Retrofit</b>				
1. <u>New shallow foundations for new shear walls (living room)</u>				
Carpet removal of the living room	30.1	m <sup>2</sup>	20	602
Cutting existing wood floor around front wall (1 m x 5.2 m)	5.2	m <sup>2</sup>	100	520
Excavation for footing incld. disposal (5.2 x 0.5 x 0.8 m <sup>3</sup> )	2.1	m <sup>3</sup>	75	158
New CIP concrete strip footings (5.2 x 0.3 x 0.4 m <sup>3</sup> )	0.6	m <sup>3</sup>	1,500	900
New wood pony foundation walls:				
38 x 140 @ 400 c/c stud pony walls	10	no.	85	850
12.7 mm plywood to one side of pony walls	2.1	m <sup>2</sup>	50	105
16 dia. Hilti HAS rod anchors @ 800 c/c c/w Hilti HIT RE500 adhesive anchor embed 150	6	no.	85	510
Manual backfilling	1.5	m <sup>3</sup>	60	90
Redo wood floor	5.2	m <sup>2</sup>	350	1,820
New floor finish/carpet	30.1	m <sup>2</sup>	80	2,408
Allowance for miscellaneous & make good	10%	%	7,963	796
			Sum	8,759
2. <u>New plywood shear walls (living room)</u>				
Remove existing walls	9.6	m <sup>2</sup>	25	240
New wood shear walls:				
38 x 140 @ 400 c/c stud & blocking	10	no.	85	850
12.7 mm plywood to both sides of walls	9.6	m <sup>2</sup>	100	960
16 dia. Hilti HAS rod anchors @ 800 c/c c/w Hilti HIT RE500 adhesive anchor embed 150	6	no.	85	510
Redo exterior wood cladding	9.6	m <sup>2</sup>	90	864
Paint to interior	9.6	m <sup>2</sup>	12	115
Paint to exterior	150	m <sup>2</sup>	13	1,950
Allowance for miscellaneous & make good	10%	%	3,539	354
			Sum	5,843

Description	Qty.	Unit	Rate (\$)	Amount (\$)
<b>3. <u>Interior walls upgrade to blocked plywood shear walls</u></b>				
Remove existing walls	30	m <sup>2</sup>	25	750
New wood shear walls:				
38 x 140 @ 400 c/c stud & blocking	27	no.	85	2,295
12.7 mm plywood to both sides of walls	30	m <sup>2</sup>	100	3,000
16 dia. Hilti HAS rod anchors @ 800 c/c c/w Hilti HIT RE500 adhesive anchor embed 150	15	no.	85	1,275
Redo wood drywall skin	30	m <sup>2</sup>	60	1,800
Latex paint to walls	60	m <sup>2</sup>	12	720
Reinstate millworks and specialties	1	sum	2,500	2,500
Allowance for miscellaneous & make good	10%	%	12,340	1,234
			Sum	13,574
<b>4. <u>Roof diaphragm upgrade to blocked plywood diaphragm</u></b>				
Remove existing ceiling board and T & G decking	126.44	m <sup>2</sup>	25	3,161
New plywood blocking	108	no.	45	4,860
New 12.7 mm plywood boards for decking	126.44	m <sup>2</sup>	50	6,322
New 9.5 mm plywood boards for ceiling	126.44	m <sup>2</sup>	40	5,058
Latex paint to ceiling	126.44	m <sup>2</sup>	12	1,517
Allowance for miscellaneous & make good	10%	%	20,918	2,092
			Sum	23,010
<b>5. <u>Interior wall top connections</u></b>				
Allowance for steel angle connection	1	sum	4,600	4,600
			Sum	4,600
<b>6. <u>Electrical &amp; mechanical work</u></b>				
Electrical work	126.44	m <sup>2</sup>	50	6,322
Mechanical work	126.44	m <sup>2</sup>	80	10,115
			Sum	16,437