Opportunities and Regulatory Barrier for the Reuse of Salvaged Dimensional Lumber from Pre-1940s Houses

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"It has been said that our old growth forests still stand — not in our forests, but in our buildings. Think about all that wood, every timber that makes up the bones of our homes, our schools and our workplaces. There's a lot of it, and it is reusable."
(Delta Institute, 2012, p. 5)

Executive summary

One third of the total solid waste in Metro Vancouver, is Construction, Renovation and Demolition (CRD) waste. Close to 90% of the CRD waste that is directly going to landfill in Metro Vancouver is from demolition projects. Compared to commercial buildings, one-two family houses have been far less successful in diverting demolition waste. Wood is the predominant material in single family homes in Vancouver and studies indicate that most of this wood is divertible and should not be sent to landfills.

Old houses are a valuable source of high-quality wood from old-growth forests. Despite all the environmental, heritage, and social benefits of building deconstruction and salvage material reuse (specifically wood materials), this is yet to become the common practice in Vancouver.

To support the Greenest City Action Plan and the Green Demolition Bylaw of the City of Vancouver, this project aimed to assess opportunities and regulatory barriers to reuse of non-contaminated dimensional lumber from houses built in 1940s or earlier in Vancouver. The project entailed three components:

1. Identifying the quantity, type, quality, and salvageability of dimensional lumber in pre-1940s houses:
   This information was collected through literature review, site visit of a heritage house renovation project, and interview with the experts in the field. The result indicated that there are about a total of 330,000 m^3 (135,000 tonnes) of dimensional lumber in pre-1940s houses in Vancouver. About 75% of this dimensional lumber is salvageable, i.e. about 250,000 m^3 (100,000 tonnes). This is equivalent to the quantity of dimensional lumber used today to build more than 8,000 single/multi-family houses. From this stock of salvageable lumber about 3,000-4,000 m3 (1,000-1,500 tonnes) will be available each year. This is equivalent to the framing lumber required to build 100-130 houses, which is about 10% of the average yearly new building permit for one-two family houses in the City of Vancouver.

2. Evaluating the current market for salvaged framing lumber:
   The study showed that there is not a considerable supply and demand in the market for salvaged dimensional lumber from old houses. Very few construction, renovation, and furniture companies use this wood in their projects. However, they mostly use salvaged lumber from an old house in the new house they build on the same site or for small personal projects. This wood is mostly used for fixtures, millworks, and furniture.

3. Identifying the opportunities and regulatory barriers for salvaged dimensional lumber reuse:
   The study showed that:
   - In the current market, salvaged dimensional lumber is more expensive than new. This is mostly because of the high labor cost for demolition and processing of this lumber.
   - Salvaged lumber has different characteristics compared to new lumber. It is denser, dryer and harder on tools, and larger in dimensions (A n old 2×4 (pre-1930) is actually 2 inches by 4 inches, whereas a new 2×4 is 1.5 inches by 3.5 inches)
   - Salvaged lumber needs to be regraded to be reused structurally. However, current grading rules do not specify methods for re-grading lumber. Therefore, graders are not able to regrade and stamp salvaged lumber for structural uses. It is only engineers who are eligible to sign off salvaged lumber for structural reuse.

It is stated in the literature that to reduce the cost and facilitate structural reuse of wood, authorities need to establish rules and techniques for regrading lumber. However, considering the low quantity of dimensional lumber in old houses (about 1% of the total wood waste that the City of Vancouver generates), establishing new grading rule for this lumber may not be a high priority. Moreover, the high quantity and special character of framing lumber from old houses make it attractive for specialty and niche product markets such as craft furniture and high quality millworks and fixtures for interiors.

The report provides information for small project teams on how to access and process salvaged dimensional lumber. It also provides them with some recommended reuse opportunities for this lumber.

In addition the report provides recommendations for the City of Vancouver and other governmental organizations to incentivize and facilitate salvaged wood reuse. The most important recommendations are:

- Mandating audits of salvageable materials in all the public projects and a percentage of salvaging to secure the deconstruction and reuse market.
- Develop an official webpage that provides educational documents, contact information, and other resources for material reuse in buildings.
- Announce best practice projects publicly through social media and COV webpage, to make reuse visible and marketable
- Support the development of a Reuse Centre, which provides all the services related to material salvaging and reuse.
- Support creating a standard stamp that specifies salvaged wood components with a short story about their past life.
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- Support the development and marketing of other upcycled alternatives such as panel board mills, biomass, and animal bedding for non-salvageable wood.
- Incentivise and encourage design for future deconstruction in new building

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1. Introduction

The wood stock in our existing buildings is a valuable source of wood, most of which is from old-growth forests. This high-quality source of wood is particularly of value for those in specialty or niche products market.

Keeping this wood source in the material flow has considerable positive environmental impacts, such as saving landfill spaces, reducing the pressure on the ecosystem by protecting trees to be cut down, and storing embodied carbon in the wood. “A Life Cycle Analysis (LCA) study by the United States Forest Service Research and Development determined that embodied primary energy (fossil fuel and biomass) consumption was 15 times less in reused framing lumber compared to their virgin counterparts. Likewise, embodied CO_2 emissions were about four times less in reused framing lumber than in their virgin counterparts” (GreenSpec, 2012 cited in Ergun, 2014). Figure 1, shows the result of a study by the Building Research Establishment (BRE). The graph indicates that, based on the environmental indicators considered in their research, reused wood studs have a considerably lower environmental impact than virgin wood” (GreenSpec, 2012 cited in Ergun, 2014). In addition to its heritage and its significant environmental impacts, material reuse also provides local job opportunities in the deconstruction and reused market (Bratkovich, Bowyer, Lindburg, & Fernholz, 2009).

This study is conducted in response to the growing awareness of the industry regarding the necessity of changing our current practices in relation to building deconstruction. It is a necessity to further prioritize material reuse due to its environmental, social, and overall economic benefits (Delta Institute, 2012, p. 5).

The information in this report is provided in two categories. The main text in the report is the suggested information to be included in a guide for architects, interior designers, homeowners, and contractors. This guide will provide some information and resources on how they can reuse salvaged framing lumber from pre-1940s houses in their projects. The information in the boxes is further background or detail data supporting the parts that are suggested for the guide.

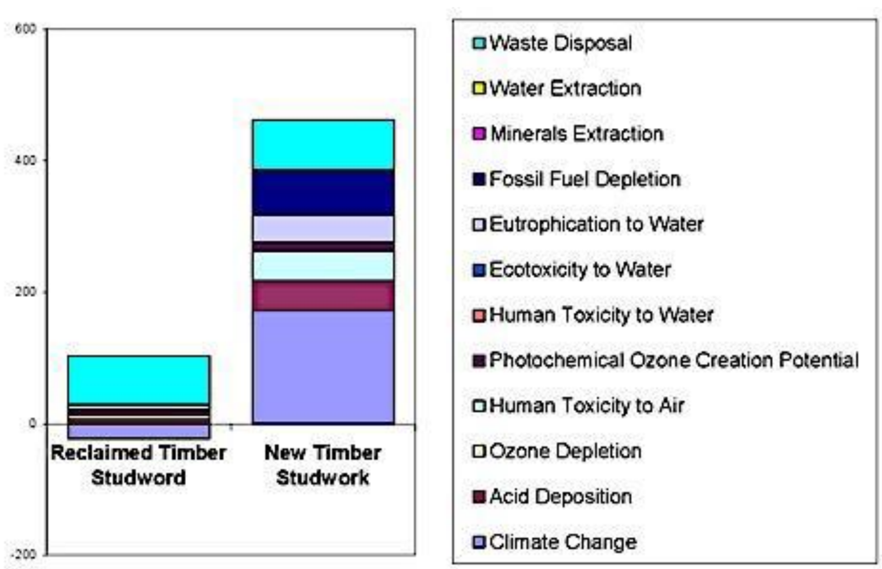


Figure 1 Environmental impacts of reusing wood studs compared to using new, where the y-axis outlines relative environmental impact (GreenSpec, 2012 cited in Ergun, 2014)

2. Why reuse?

Various environmental, social/cultural, and economic benefits of reuse have been discussed by various industrial and academic researchers. Below are some of these benefits:

Environmental

- Reuse is the second environmentally preferred waste management strategy (Figure 1).
- Reuse reduces the need to landfill materials.
- Reuse reduces the need to disrupt ecosystems to harvest virgin wood.
- Reuse reduces the energy needed to access and process virgin materials.

Aesthetic, historic, and social

- Old salvaged wood products are sourced from old-growth forests. These add significant character to design,
- Lumber from old houses brings stories of the past to the new buildings,
- Deconstruction and preparation of salvaged materials provide local green job opportunities.

Economic

- Some salvaged materials may be more expensive than new, because of their heritage and character or because of the high cost of labor involved in the recovery and refurbishing processes compared to the low price of new materials. However, salvaged materials can be still a more financially reseonable option in the long-term. For instance, old wood offer close grain finish and is extremely hard wearing and durable.

Green market recognition

- Gaining gain recognition in the green building market is another indirect financial motivation for using salvaged materials.
- Some green building programs such as Leadership in Energy and Environmental Design (LEED) or Built Green or certification standards such as Forest Stewardship Council (FSC) give credit to reusing salvaged materials/products.

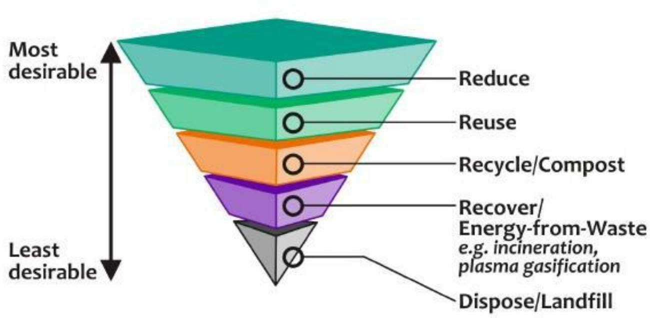


Figure 2 Reuse is second in the hierarchy of waste management strategies based on their environmental impacts (City of Ottawa, 2012, cited in Ergun, 2014)

2.1. Environmental benefits

One third of total solid waste in Canada and also in Metro Vancouver, is Construction, Renovation and Demolition (CRD) waste. Close to 1.6 million Tonnes of CRD waste is generated in Metro Vancouver. It is estimated that more than half of the CRD waste that is sent to landfill can readily be diverted.

City of Vancouver's Greenest City Action Plan aims to achieve 50% waste by 2020 from 2008 level. Metro Vancouver's Solid Waste Management Plan (SWMP) has set even more rigorous targets: 80% by 2020, and 10% reduction in waste generation by 2020 (Dalal, 2011). As part of the Greenest City Action Plan, City of Vancouver intends to achieve 11% reduction in CRD waste that is sent to landfill.

Recent studies criticize that current policies and strategies fail to place sufficient emphasis on the waste management hierarchy (Figure 2). These studies assert that recycling, which is lower than reuse in the hierarchy, is the most supported strategy in current assessment methods, practices and policies. Current recycling practices move material flows toward becoming more impure and losing their quality through time (Sassi, 2004).

Reuse is the second preferred solution in the waste management hierarchy (Figure 2) with minimal negative environmental impacts. It helps reducing CO_2 emissions, energy, resources, and land use by reusing existing materials stock in the built environment (Ergun, 2014). These benefits are more considerable if salvage materials are sourced locally (Delta Institute, 2015).

2.2. Aesthetic, heritage, and social benefits

Salvaged materials often have higher quality, are more durable, provide unique character than new materials. Old materials are a slice of the past and bring the story of their past life to the new building. Chini and Bruening (2005) emphasize that people have a natural interest in preserving those things that represent memories of past cultures, places, and ideologies.

Other than the aesthetic and heritage value of material reuse, deconstruction and reuse market create local green job opportunities. Deconstruction needs "a more tender touch … than many demolition machines can provide". Therefore more workers are hired in a deconstruction project compared to demolition. Deconstruction and reuse also create some new job opportunities such as: workers for de-nailing, reused building material retailers, transportation and logistics, and skilled craftsmen (who do the hands-on work of dismantling structures and handling materials for reuse and also those who build value-added products) (Delta Institute, 2012, p. 23) Moreover, deconstruction can be an opportunity for training local construction workforce through the reverse construction process (Falk R. , 2002).

2.3. Economic benefits

Salvaged materials are not always cheaper than new. The higher price of salvaged materials can be because:

- Some of the salvaged materials, such as old wood, have actually a higher quality than the materials we can buy today.
- Some salvaged materials are considered to have character.
- The preparation of salvaged materials for reuse can be time consuming and labor intensive (Falk, 1999; Falk and Guy, 2007).
- The market for salvaged materials is not well developed, which makes it difficult and costly to obtain them.

Despite their higher price, salvaged materials may still be an attractive option for high-end projects, due to their higher quality, unique character, and durability. Moreover, as the market for used materials grows, the price of salvaged materials will be reduced as a result of easier access and better technology that will be available.

A few case studies of deconstruction (mostly in Washington State, US) have shown that that demolition can be more costly than deconstruction when savings from reduced landfill fees, tax deduction from donating salvaged materials, revenues from selling salvaged materials, or reduced cost of new material purchase are factored in. This is promising news for the reuse market, because if deconstruction is financially feasible, it can be encouraged as the common practice. As a result, more salvaged material will be available in the market. This will reduce the cost of salvaged materials and make them a viable alternative for new materials.

"The ReUse People of America estimate that the cost to demolish a single-story 2,200- square-foot house is roughly $10,000. However, it is not unusual for a homeowner to offset the higher cost of deconstruction (which can cost more than twice as much) through tax deductions from donation of building materials. Documentation by a third-party appraiser is required for donations of more than $5,000. Despite this additional step, tax deductions have been an important benefit in residential deconstruction." (Delta Institute, 2012)

Another example of house deconstruction and salvaging in Vancouver Island was conducted by Dave Bennink, RE-USE Consulting. Using salvaged wood in the new construction in this project lead to $20,000 saving in material cost. The deconstruction cost was $18,000, whereas demolition cost would have been $12,000. This project not only saved $2000 as a result of deconstruction and material reuse, it also created more job opportunities for deconstruction staff.

It should be noted that even if in an individual scale, deconstruction and material reuse be more costly than demolition and using new materials, in a lifecycle perspective they can be the preferred option. It is because in assessing the cost of demolition, the future costs to the municipalities or private landfills are not taken into account. One example is the cost of capturing the GHG emissions created from landfilling wood. Moreover, building deconstruction and material reuse can create a local economic multiplier effect (Guy & McLendon, 2000). A multiplier effect happens when creating new local jobs indirectly stimulates employment in other businesses in the region. It is because the financial resources will go to local jobs and will be spent in the local markets, rather than being invested on landfills.

2.4. Green market recognition

Another indirect financial motivation for designers and contractors to use reclaimed materials is to gain recognition in the green building market. Green building programs such as Leadership in Energy and Environmental Design (LEED) or Built Green or certification standards Forest Stewardship Council (FSC) give credit to reusing salvaged materials/products.

- **Forest Stewardship Council (FSC)**

The Forest Stewardship Council (FSC) has a standard for sourcing reclaimed wood that allows materials to be included in FSC labeled certified products.

Relevant examples of Reclaimed Wood Recognized by FSC (Bratkovich, Bowyer, Lindburg, & Fernholz, 2009, p. 10):

- Post-consumer wood sources;
- Municipal Sources;

- Construction and Demolition Debris;
- Residential (Single Family Homes, Multi- Family Dwellings);
- Construction and Demolition Debris including doors, flooring, old cabinets, moldings, and dimensional lumber, discarded wood packaging e.g. pallets and cable drums;
- Wood reclaimed through 'Deconstruction e.g. salvaged dimensional lumber and architectural elements;
- Damaged Stock and Rejected Products manufactured from post-consumer wood products, including deconstructed building materials, or wood reclaimed from construction and demolition (C&D) debris;
- Used building materials, furnishings, cabinets, shop fittings, shelving etc. that have been used for their intended purpose by residential consumers.

- **Leadership in Energy and Environmental Design (LEED) for Homes (V4)**

The latest version of Leadership in Energy and Environmental Design (LEED) for Homes (V4), developed by the United States Green Building Council (USGBC), requires all the projects to use wood that is reused or reclaimed, or certified by FSC or some equivalent certification program. The assessment system gives up to 4 points to projects that reuse materials in framing, flooring, floor covering, sheathing, interior finishing, siding, cabinets, doors, counters, trims, decking and patio materials, and windows.

- **Built Green Canada**

Built Green is an industry-driven national sustainability certification program for the residential sector. Built Green gives 6 points to the projects that use local reclaimed wood for flooring, or all cabinets, or all millworks.

3. Why framing lumber from pre-1940s houses?

3.1. Why wood waste?

58% of the CRD waste that is sent to landfill in Metro Vancouver is wood waste (Metro Vancouver, 2015). According to Metro Vancouver's estimations less than half of the wood waste generated in the region is recycled. To encourage wood waste diversion, Clean Wood Disposal Ban has been introduced on July 1, 2015 to all Metro Vancouver and City of Vancouver transfer stations and disposal facilities. At these facilities half the surcharge will be applied to all loads of garbage containing clean wood[1] if the quantity of wood exceeds 10% of the garbage load. (City of Vancouver, 2014c)

3.2. Why framing lumber from pre-1940s houses?

Close to 90% of the CRD waste that is directly going to landfill in Metro Vancouver is from demolition projects. Compared to commercial buildings, one-two family houses have been far less successful in diverting demolition waste (approximately 40% recycling/reuse in one-two family houses as opposed to the 85% in commercial buildings). Wood is the predominant material in single family homes in Vancouver (about half by weight) (City of Vancouver, 2014c).

[1] Clean Wood is defined as solid wood, lumber, and pallets that are unpainted, unstained, untreated, and free of glue. The wood may be pierced with nails or other metal fasteners, such as screws and staples.

Moreover, despite their old and unappealing surface look, wood from older buildings (pre-1940 houses and especially those built pre-1930s) generally have better mechanical and aesthetic qualities compared to the wood sold today (see Figure 3). This wood is commonly from old-growth forests, which have been depleted since then. It is slower growth, tend to have higher density, tighter grains, fewer defects, and be in larger cuts[2] (Falk R. H., 1999; Ergun, 2014; Bratkovich, Bowyer, Lindburg, & Fernholz, 2009; Falk and Guy, 2007).

To support the mentioned advantages of salvaging from pre-1940 houses, the City of Vancouver enacted the Green Demolition Bylaw in September 2014. According to this bylaw all the development and building/demolition permit applicants for the pre-1940's homes will have to deconstruct[3] and demonstrate reuse or recycling of at least 75% of the waste material or 90% for houses that are identified as character buildings in accordance with procedures set out by Planning and Development Services. The goal of this bylaw is to encourage retention of these buildings or their character materials/components (City of Vancouver, 2014c). This bylaw supports the growth of the reuse market as more material/product is being salvaged.

Figure 3 A section view of a 2×4 lumber taken out from a 1920s heritage house in Vancouver (735 22nd e)

[2] A pre-1930s 2×4 has the actual size of 2 inches by 2 inches, whereas the new 2×4 is actually 1.5 inches by 3.5 inches.
[3] Deconstruction maximizes the quantity of reusable items in an old building by maintaining the quality of materials/products through careful dismantling (Bratkovich, Bowyer, Lindburg, & Fernholz, 2009).

4. How much dimensional lumber is available in pre-1940s houses?

It is estimated that there is about a total of 330,000 m^3 (about 135,000 Tonnes) of dimensional lumber available in pre-1940s houses in Vancouver. However, not all the materials in old houses are salvageable. A portion of dimensional lumber is damaged as a result of its use in the house (Figure 5), deconstruction process, or preparation of the lumber for reuse (de-nailing, cleaning, and re-milling). Moreover, some of the lumber in old houses has lots of nail it, which makes the de-nailing process time consuming and non-efficient (Figure 6). Almost 75% of the dimensional lumber is salvageable, i.e. about 250,000 m^3 (about 100,000 Tonnes). This is equivalent to the quantity of dimensional lumber used today to build more than 8,000[4] single/multi-family houses. From this stock of salvageable lumber about 3,000-4,000 m^3 (1,000-1,500 tonnes) will be available each year as houses are being deconstructed[5]. This is equivalent to the framing lumber required to build 100-130 houses, which is about 10% of the average yearly new building permit for one-two family houses in the City of Vancouver during 2011-2014 (1280 permits) (City of Vancouver, 2015).

Figure 4 Framing structure (2×6 joists and rafters, 2×4 studs, and sheathing) of a 1920s house

[4] Today's housing with the average size house of about 2200 ft. uses about 13,000 BF (13 tonne) of framing lumber (Falk R. , 2002).

[5] Assuming about 360-480 pre-1940s houses being deconstructed each year. 900-1200 Demolition permit is granted each year by the City of Vancouver, from which 40% are pre-1940 (City of Vancouver, 2014c)

Figure 5 damages in lumber used in a 1920s house

Figure 6 Some dimensional lumbers (specially 2×4 wall studs) have lots of nails which require a lot of labour to remove

There are various studies in the literature that estimate the reusable and recyclable materials stock in existing buildings (Falk & McKeever, Recovering Wood for Reuse and Recycling: A United Stated Perspective, 2004; Ergun, 2014; Falk R. , 2002; Ergun, 2014). Single-family houses have are of special importance in these studies as they are highly prone to redevelopment particularly in large and developing cities (Ergun, 2014).

US EPA estimates that salvageable structural lumber in single-family houses is about 1.8 million m^3 per year which is equivalent to about 3% of the US softwood harvest (Falk & McKeever, Recovering Wood for Reuse and Recycling: A United Stated Perspective, 2004). In a study on reusable materials stock in single-family houses in Toronto, Ergun (2014) used samples of each house archetypes in Toronto to calculate the quantity of salvageable materials in each archetype and estimate the total salvageable stock based on this calculation.

According to previous case studies from the United States and Australia 50% to 90% of framing lumber is recovered in deconstructed buildings. Falk R. H. (1999), suggests considering a 25% loss in the recovery of framing dimensional lumber, due to the damage in the deconstruction process (Ergun, 2014).

The current study estimated the quantity of framing lumber in pre-1940s houses in Vancouver, using data from a previous project conducted by a group of UBC students for the City of Vancouver to estimate the quantity of waste in single/multi-family houses (Wegner, et al., 2015). The author of this report also consulted with some people in the industry[6] and an architecture professor at UBC[7] to identify the most feasible method for estimating the quantity of salvageable lumber in pre-1940s houses. In the final method, the quantity of each lumber size was estimated (2×4, 2×6, and 2×8) in a hypothetical square plan two-storey house with a basement. The area of each floor was assessed using the average floor area of a number of sample pre1940s houses in Vancouver. The estimation showed that for a square-planned two storey house with the total floor area of about 2000 sqft, there is about12 m^3 (about 5 tonnes) of framing lumber in a pre-1930 house and about 8 m^3 (about 3.5 tonne) in a 1930-1940s house. It is assumed that in pre-1930 houses lumbers have full dimension, whereas in 1930-1940s houses the dimensions of lumbers are not actual (e.g. 2×4 versus 1.5×3.5). The quantity of lumber in the hypothetical house was then multiplied by the total number of existing pre-1940s houses and the number of houses that are estimated to be demolished each year. The calculation indicated

5. How to reuse it?

This section provide information required for small project teams (designers, constructors, and owner/developers) to use salvaged dimensional lumber in their projects. This include information regarding where they can find salvaged lumber, how they can prepare it for reuse, and where they can use it. The section also talks about the role of different stakeholders to make material reuse more feasible and successful.

[6] Dave Bennink: deconstruction expert, RE-USE Consulting and Peter Moonen: Municipal Affairs and National Sustainability Manager, WOOD WORKS!, Canadian Wood Council

[7] Greg Johnson, School of Architecture and Landscape Architecture, UBC

5.1. Where to find it?

A list of local businesses that provide or work with salvaged framing lumber can be found in Appendix A.a. This list is periodically updated in this link[8].

Figure 7 Salvaged dimensional lumber available in J&S reclaimed Wood

[8] COV can provide a list of the businesses online (in its reuse link) that will be updated periodically. Example of such website is the reuse page of the City of Portland.

5.2. How to prepare it?

Reclaimed lumber is the most desirable and useful if it is packaged and sorted according to the standard lumber sizes and lengths[9], so that it is comparable with new lumber. It is easier to use reclaimed materials that are processed and sourced by retailers. However, processed (de-nailed, cleaned, re-milled, and refinished) lumber may be more expensive than unprocessed salvaged lumber. As a consequence, your project team may prefer to process salvaged lumber from the existing building on your project site or from another site themselves, if they have the skills, time, and capacity for it.

The following is the process for preparing reclaimed lumber for using in your project (Living Vintage, 2014; Reclaimed Wood Exchange, 2015; Historic Woods, 2015):

[9] The common dimensions for framing lumber are: 2×4, 2×6, 2×8, 2×10, and 2×12 (inches). It should be noted that the dimensions of older lumber (especially pre-1930) is closer to the nominal dimensions. Whereas, the finished new lumber dimensions in widths and thickness are 1/2-inch less than the size. For example a 2×4 actually measures 1 1/2 inches thick and 3 1/2 inches wide. Dimensions of 2×8 and greater are 1/4-inch smaller in width. A 2×10 actually measures only 9 1/4 inches wide.

The common lengths for dimensional lumber: 6, 8, 10, 12, 14, 16 feet. Lumber with length of 18 to 24 feet is also produced, but not commonly stocked in building-supply stores

Step one: Select and sort reusable lumbers

- Separate lumber that is not painted, contaminated, broken, or cracked
- Sort lumber according to it size and type of wood. It is suggested to label the lumber with their dimension and type at least on at the end.

Step two: Remove all the metal pieces

- Remove all the nails and tacks for efficiency and safety, using hand tools such as claws and chisels or pneumatically-powered denailer tools (Figure 8 and Figure 9).
- In the case that the nails are rusty and old, it is possible that the head would pop off. A nipper or needle nose plier can be used to pull the stub that is in the wood.
- If lumbers are re-milled in machines, use metal detector to ensure there is no metal remained in it (Figure 10)

Step three: Trim all the edges

- Trim the lumber to remove the damaged edges. These edges also have more nails in them
- Try to keep the lenghth of the lumber as long as possible and cut it when you identified its reuse function

Step four: Kiln Drying (Not crucial for non-structural purposes)

- Although the salvaged wood is very old and well seasoned, kiln drying gently draw out ambient moisture and unify the boards moisture content and eradicate stray critters that possibly occupy the wood long after it offers much nutrient value.

Step five: Regrading (If lumber is used structurally)

- Currently there is no standard rule for re-grading salvaged lumber for strudtural use. Therefore, the project structural engineer should sign off on the structural integrity of lumber if it is going to be used for structural purposes (see section 6.5).

Step six: Sizing/planning/refinishing (If lumber is used decoratively)

- Wood can be remilled to be resized to the standard size, if it is is going to be used struturally or to be sized for the intended second use.
- Wood can be planed to remove the old rusty surface to be used in decorative uses (Figure 11).
- Wood can be wire brush and sand the surfaces to remove any loose wood, dirt and debris (Figure 11).

Figure 8 De-nailing of lumber (the source for the picture on the right: (Delta Institute, 2012)

Figure 9 A pneumatically-powered de-nailer tool

Figure 10 Using metal detector to ensure there is no metal in the wood for re-milling (West Coast Reclaimed Lumber)

Figure 11 Planning, gluing, and refinishing of 2×4s to be reused as stair tread (by: Naturally Crafted Construction)

5.3. Where to reuse it?

Building deconstruction and salvaging often yields a wealth of wood, both finished wood and dimensional lumber. Therefore, as the market for deconstruction matures, salvaged finished wood and smaller dimensional lumber will be more and more available. Much of this wood is of high quality, and in many cases superior to new wood products (Metro Oregon, 2007). However, when starting a new project, it may be difficult and tedious to decide how to use salvaged materials. This section explains to owners, developers, designers, and contractors how to include salvaged materials in their house. It introduces possible ideas intended to arouse a design team's creativity in an efficient manner.

Although it might be time consuming and costly to re-grade salvaged lumber for structural use with current grading rules (see section 6.5), structural wood can be re-graded and reused as structural wood (Davis, 2012; Falk, Devisser, Cook, & Stansbury, 1999; Falk, Maul, Cramer, Evans, & Herian, 2008). In one example Emergent Structures, a non-profit organization in the United States, recovered and reused 770 studs to construct roof trusses in cost-efficient housing projects (Emergent Structures, 2010). It is more common and acceptable by building inspectors to maintain an existing structure in a house renovation or re-development project rather than using salvaged lumber in a new structure. It is because the performance of an existing structure has been proven through time, but there is no certainty about the structural integrity of a salvaged lumber from another building without re-grading it (Ed Loney, see section C).

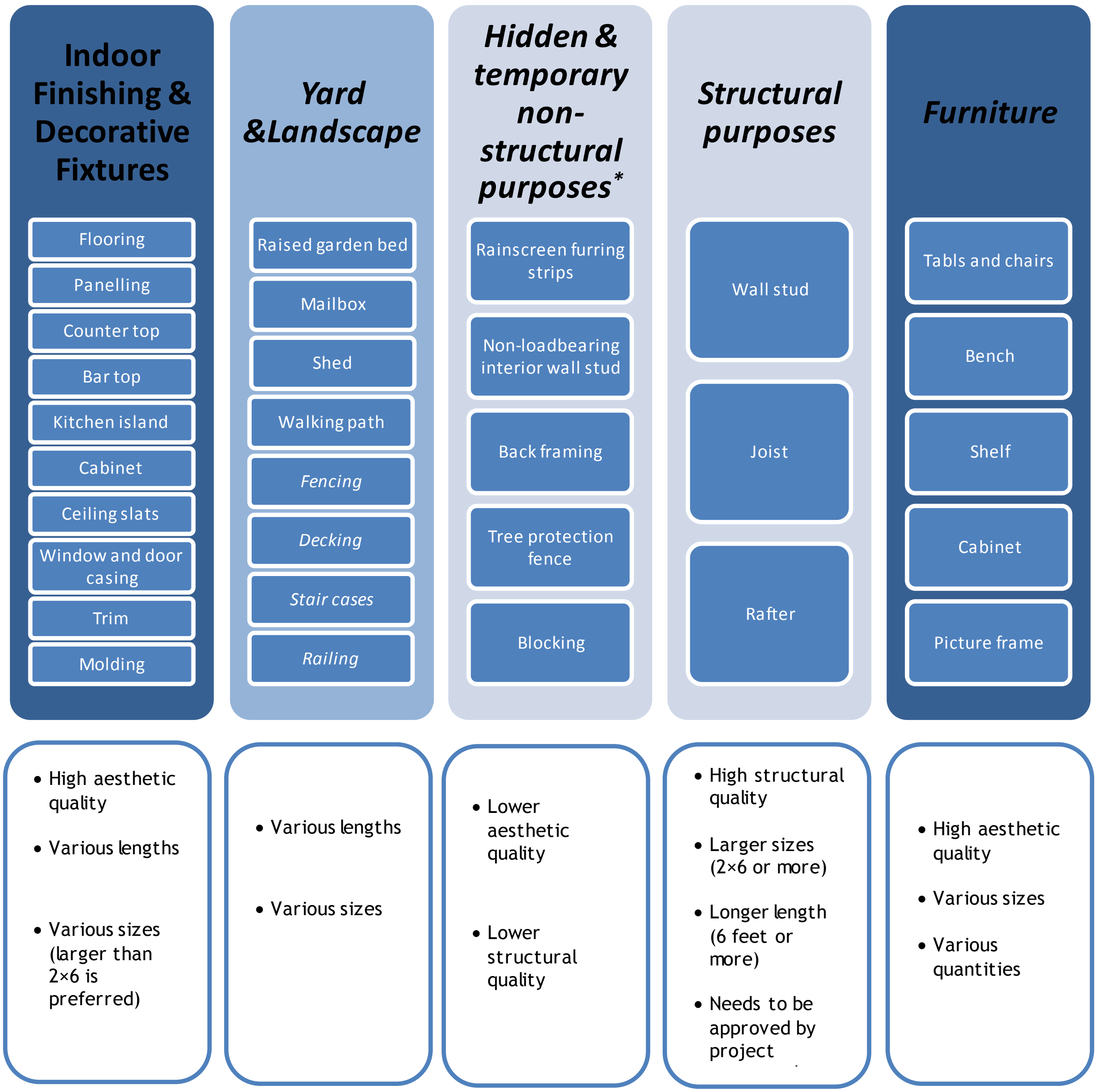
With current complications to reusing salvaged lumber structurally, most often it is more practical to reuse this lumber for non-structural purposes such as non-loadbearing wall studs, blocking and building shelves. Project teams can sand, paint (see Figure 11) and reuse finish wood for purposes such as flooring, panelling, siding, and molding (Metro Oregon, 2007; Ergun, 2014). According to the US army corps of engineers (2005) 2×6 or larger lumber can be used for paneling, molding, trim, and hardwood flooring, while 2×4 or smaller can be recycled. Although it is most commonly accepted among the experts in the industry that it is yet not very economical to salvaged 2×4 that have lots of nail in them, some companies such as Naturally Crafted Construction have successfully used 2×4 for decorative finishing and fixtures (see Figure 16, Figure 17, and Figure 19).

The following sub-sections provide some examples of salvaged lumber reuse in the functions recommended in Figure 12.

Type of lumber	Suggested use				
	Indoor Finishing & Decorative Fixtures	**Yard &Landscape**	**Hidden & temporary non-structural purposes**	**Structural**	**Furniture**
2×4					
2×6					
2×8					
2×10					
2×12					

Table 1 Recommended functions for different dimensions of salvaged lumber

Figure 12 Reuse opportunities for dimensional framing lumber



*Using salvaged lumber for hidden non-structural uses may not be a favorite choice for contractors. It is because this lumber is hard on tools, very dry and difficult to work with.

For structural use, lumber should have the required structural grading stamp specified in the Vancouver Building Bylaw (see Table 2) (City of Vancouver, 2014b). Therefore, salvaged lumber needs to be re-graded to be used structurally. Currently, grading rules and guidelines take into account fresh cut dimensional lumber and do not include salvaged wood (holes, checking, etc.). Reclaimed lumbers are subjected to the long-term effects of "loading, damage from installation and deconstruction, and multiple nail holes." Because these consequences have not been properly accounted for, the reclaimed lumber may be downgraded in the grading process (Davis, 2012). Some of the defects previously stated may not noticeably hinder the mechanical properties but, rather, adds an aesthetic factor to the wood. The issue with not having a grading scale is that the exact condition of the lumber cannot be identified without a physical inspection. Therefore, only structural engineers who are familiar with rules for lumber grading are eligible to sign off on the structural integrity of salvaged lumber, not lumber graders[10]. As a result, structural use of lumber is more relevant to the visible structures in custom, high-end projects (Geller, 1998), where the client is willing to spend extra time and money to use structural reclaimed lumber for the aesthetic and environmental benefits of it.

An important consideration in reusing salvaged dimensional lumber for exterior wall studs, roof rafters, and ceiling joists is the compliance with the insulation requirements in the Vancouver Building Bylaw[11] (City of Vancouver, 2014b). For instance, while in old houses the wall studs were commonly 2×4, using 2×4 studs requires using specific wall assemblies to achieve the thermal performance required by the building bylaw (see RDH Building Engineering Ltd. (2015, p. 6))

Manufacturers that buy stock for flooring, paneling, and siding and any product that is run with a shaped pattern, are meticulous about the quality and safety of the product. These manufacturers are not willing to risk their equipment and time for a reclaimed wood that is not demanded by market. The successful examples of reclaimed flooring manufacturers exclusively use reclaimed wood in their operation and run integrated, mid-sized facilities. The reclaimed wood for flooring can range from clear, vertical grain, to lumber with lots of nail holes and streaks of mineral and rust stains in it (naily grade). As for the length, it can be as short as three feet if the millwork equipped with modern tools.

For paneling and siding an average grade lumber can be used. Given a good distribution reclaimed paneling and siding can sell fast. Paneling can use short or random-length lumber, however siding requires long lumber.

Architectural millwork can include a variety of molding, trim, rail, and sill patterns. The producers of architectural millwork look only for extra clean stock. For example, reclaimed wood with knots, checking and any type of fastener marks is unacceptable. Dry, dense, and old-growth lumber is difficult to come by in new market. Therefore, an aggressive grading to extract the highest quality material and use of technology such finger jointing leads to a marketable and lucrative product (Geller, 1998).

[10] According to Allan Rozek, the executive director of National Lumber Grades Authority (NLGA), currently graders are not qualified to re-grade lumber for structural purposes

[11] The 2014 Vancouver Building Bylaw requires an R-22 or greater effective thermal performance. "This level of thermal performance represents a significant increase in the required level of performance from previous codes". For more information please see: (RDH Building Engineering Ltd., 2015).

Table 2 Minimum Lumber Grades for Specific End Uses (City of Vancouver, 2014b, Table 9.3.2.1.)

Function	grades
Wall stud framing (loadbearing members)	Stud, Standard, No. 2
Wall stud framing (non-loadbearing members)	Stud, Utility, No. 3
Plank frame construction (loadbearing members)	No. 2
Plank frame construction (non-loadbearing members)	Economy, No. 3

5.3.1. Indoor Finishing & Decorative Fixtures

Figure 13 Kitchen Floor Made With reclaimed wood with nail holes on it (E.T. Moore Manufacturing)

Figure 14 Decorative wall and ceiling covers (J&S Reclaimed Wood)

Figure 15 [Reclaimed board used in ceiling]

Figure 16 Shelf made from reclaimed lumber ([Naturally Crafted Construction])

Figure 17 Built-in shelf made from reclaimed lumber ([Naturally Crafted Constructions]s)

Figure 18 Bathroom sink table (Photo: Simon Lee, [Canadian Salvaged Timber](), Toronto)

Figure 19 Stair treads built from salvaged 2×4 lumber ([Naturally Crafted Construction]())

Figure 20 Sliding door (Loft Doors)

Figure 21 Reclaimed Hardwoods Wall-Panelling (J&S Reclaimed Wood)

Figure 22 Window trim from salvaged wood (Pure Nard Woodworking)

Figure 23 Countertop made from reclaimed wood (retrieved from the link)

Figure 24 Bar (Photo: Simon Lee, [Canadian Salvaged Timber](), Toronto)

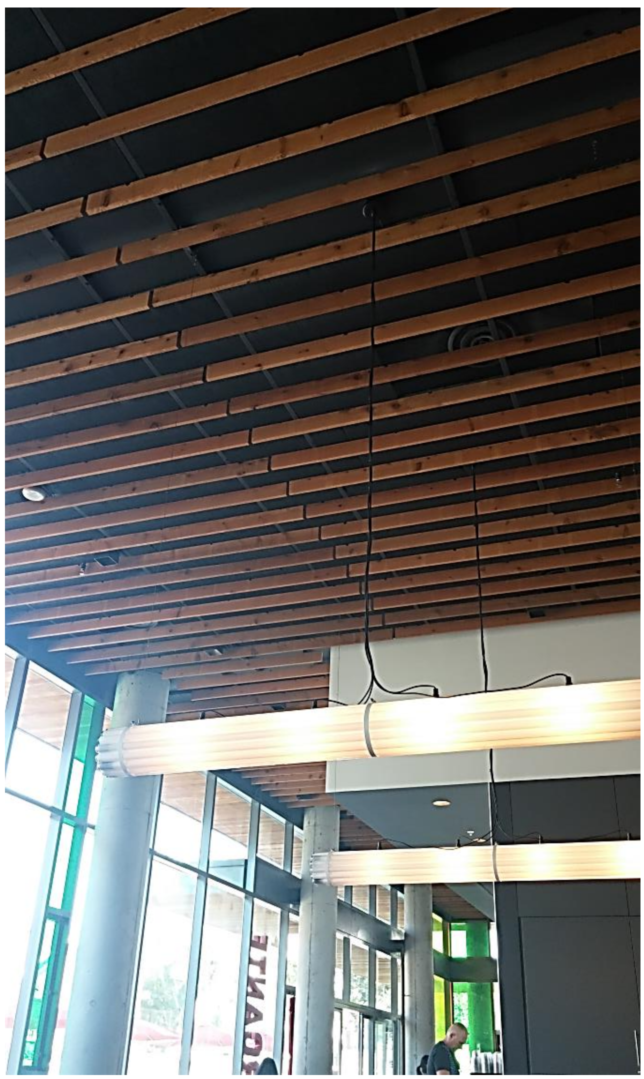


Figure 25 Ceiling slats made from dimensional lumber of the old existing building on the site, UBC

5.3.2. *Yard &Landscape*

Figure 26 Exterior elements from salvaged wood ([Naturally Crafted Construction](#))

Figure 27 Decking from reclaimed lumber ([Wood-shop worker's co-op](#))

Figure 28 Shed Made from Reclaimed lumber (Petaluma CA, Joseph Sandy)

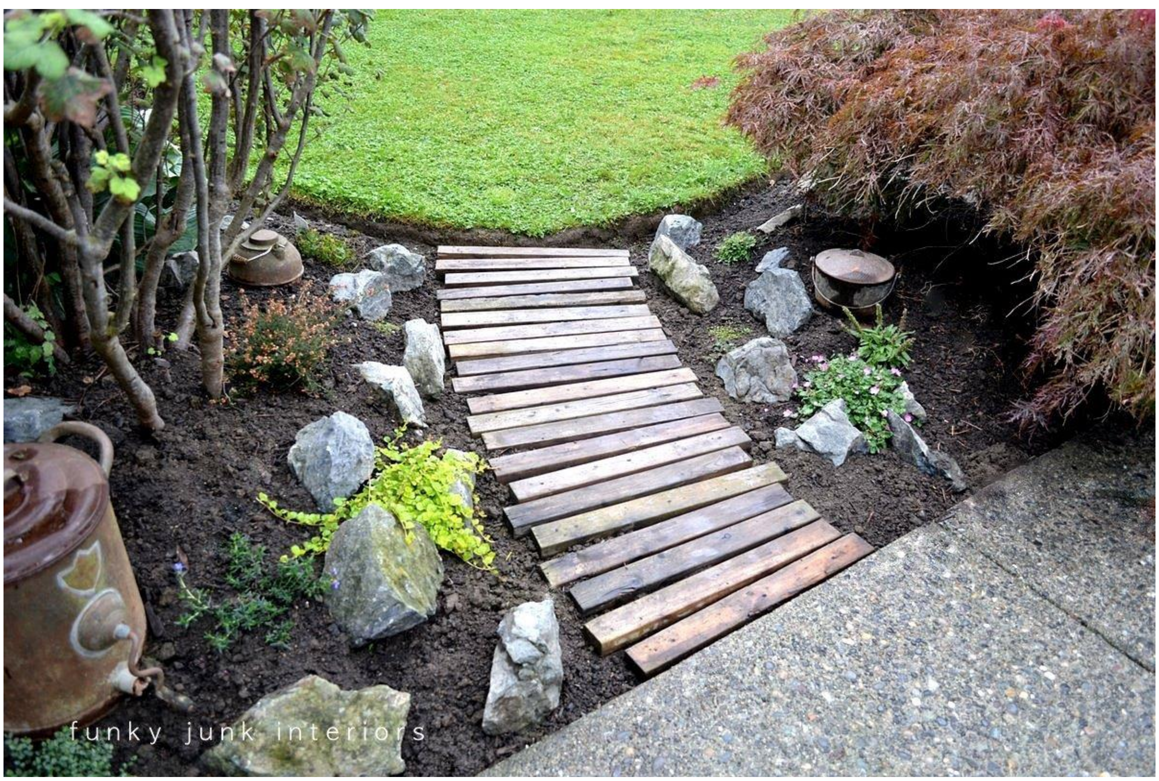


Figure 29 pallet wood reclaimed lumber outdoor garden walkway (Funky Junk Interiors)

Figure 30 Fencing (Rustic Canyon, Los Angeles, Eric Brandon Gomez)

Figure 31 Archway and bench from salvaged wood (Wood-shop worker's co-op)

Figure 32 Stair case ([Naturally Crafted Construction](#))

Figure 33 Outdoor reclaimed furniture (Photo: Simon Lee, [Canadian Salvaged Timber](#), Toronto)

Figure 34 Raised garden bed from reclaimed wood (Cambridge Wood Works)

Figure 35 Compost bin


Figure 36 Planters made with salvaged wood (left: Wood-shop worker's co-op, right: Brunch at Saks)

Figure 37 Garden Work Bench (By Jason Miller; photography by Ed Gohlich)

5.3.3. *Hidden & temporary non-structural purposes*

Figure 38 Temporary tree protection during construction

Figure 39 Temporary tree protection during construction

5.3.4. Structural purposes

Figure 40 Ceiling joists kept exposed in renovation for aesthetic purposes (Naturally Crafted Construction)

Figure 41 Old studs and joists of a heritage house supported by new lumber for structural purposes

5.3.5. Furniture

Salvaged wood can have a market outside the building industry (i.e., furniture and handcrafts), but this would be more relevant for smaller pieces and smaller quantities.
Custom furniture manufacturers are increasingly seeking reclaimed wood and using it as a selling point for their products. However, these manufacturers compete with inexpensive furniture that is mass-produced in Mexico and Asia. (Geller, 1998)


Figure 42 Reclaimed wood Table (Photo: Simon Lee, Canadian Salvaged Timber, Toronto)


Figure 43 Table made from reclaimed dimensional lumber (Naturally Crafted Construction)

Figure 44 TV table from reclaimed wood (Photo: Simon Lee, [Canadian Salvaged Timber], Toronto)

Figure 45 Console Table made from reclaimed lumber (By: [Sherry Petersik])

Figure 46 Reclaim Wood Bed (Photo: Simon Lee, Canadian Salvaged Timber, Toronto)

Figure 47 Hanging Kitchen Herb Garden made from reclaimed wood (by Julie Carlson)

5.4. What is the role of each team member?

An early coordination among the owner, design team, and contractor at the pre-design phase that continues through design and development leads to better and more innovative ways of reusing materials (Light House Sustainable Building Centre, 2011). Table 3 shows how different stakeholders play a role in successful material reuse (Metro Oregon, 2007).

Table 3 The role of different stakeholders in a project for successful material reuse

Team member	Responsibilities
Owner	• Clearly state material reuse targets to the project team in the planning stage. • Hire designers and contractors that are familiar with and motivated about reuse. • Ensure the project completion date allows for use of salvaged materials. • Earmark and specify maximum funds in the budget for the use of salvaged materials.
Designers (Architect, structural engineer, landscape designer, Interior designer)	• Design the project aiming for using salvage materials. • Keep a flexible mind to deal with the uncertainty of finding the appropriate salvage material. • For structural reuse of dimensional lumber, ensure that the project engineer can inspect and approve its use in the project. Also ensure that you communicate it with your building inspector in the early decision making stages.
General contractor	• Develop a bid package that meets the reuse requirements. • Specify salvaged materials to be used in the project specifications. • Create a work plan for storing and processing salvaged materials, if necessary. • Procure salvaged materials as you come across them and store them if there is enough space.

5.5. General tips for successful material reuse

The following are general tips on how to incorporate used material in your existing project (City of Vancouver; Vancouver Green Capital, 2010).

Plan ahead

- Find and store used products that meet your needs.
- Ensure that you keep away your materials from moisture and cold, as they can destroy your new treasure before you get the chance to use it.

Be creative

- Think outside the box when it comes to using salvaged materials, because someone else's trash could be your treasure.

Be flexible

- Keep your options open. Instead of creating a design and then hunting for the materials to make it work, why not let your discovery be your starting point?

Prioritize health, safety, and efficiency

- It's not always good to reuse. Avoid material that may introduce hazards into your home such as lead, asbestos, or unsafe electrical products.
- Do not reuse material that negatively affect your home's efficiency, such as single-pane windows.

6. What are the challenges?

The following are the main barriers for reusing salvaged dimensional framing lumber in the current market situation:

6.1. Cost of salvaged versus new lumber

"Salvage structural lumber often has a high cost to retrieve (includes wear and tear on workers, liability, as well as direct costs of accessing and processing of lumber) but typically has a lower resale value, making the economics of it imbalanced" (O'Brien & Company and Herrera, 2013). New lumber is extremely cheap while labor is very expensive, which makes reuse a costly and unreasonable option. For instance an 8-foot 2×4 lumber costs about 2$ whereas, carpenter costs $40/hr (Earle, Ergun, & Gorgolewski, 2014; Kane Consulting, 2012). See Table 4 for further price comparison.

Despite the typical higher cost of salvaged lumber, it should be noted that using salvaged lumber adds character to the new construction. Moreover, "building green can increase the value of a building and enhance the public's perception of the project and the project team." (Metro Oregon, 2007, p. 51)

6.2. Availability in desired time, with desire characteristics, and quantity

By contrast to salvaged beams and posts which have a more developed market, due to the higher demand, the market for smaller size lumber (framing lumber) is less developed. Due to the lack of demand and low value of salvaged materials, currently selective deconstruction and salvaging is not a favorable practice in the construction industry. It is due to the time requirement of such practice and lack of valuable market for salvaged materials. That is particularly a consideration for houses which are small, and do not generate considerable amount of material worth separating. As a consequence, even if the project teams are willing to use salvaged dimensional lumber in their projects, they might not be able to find the right quantity and quality of dimensional lumber at the desired time.

6.3. Hard on tools

Salvaged lumber is very dry and dense, which make them difficult to work with tools. They may damage or dull the saw blades. However, they are still softer than hardwood (See the interview with Adam Cornel, Naturally crafted construction).

6.4. Different size and look compared to new lumber

As mentioned in section 5.2, in pre-1940 houses lumber sizes are bigger than new lumber (a 2×4 is actually 2×4 before 1940s, whereas today is 1.5×3.5). The difference in the dimensions and length of new and old lumber, as well as the differences in their appearance and their physical characteristics, makes it difficult to use old lumber mixed with new.

Also, as mentioned in section 5.3, to reuse 2×4 lumber for exterior walls (as it was common in old houses), specific wall assemblies should be used to meet the thermal performance requirements in 2014 Vancouver Building Bylaw (RDH Building Engineering Ltd., 2015).

6.5. Re-grading for structural reuse (Code requirement)

The practicality of reclaimed lumber in structural applications is still being investigated. However, research is relatively limited and primarily conducted by Forest Services, a research and development program from the United States Department of Agriculture (e.g., Falk and Green, 1999; Falk et al, 2003 & 2008), or by testing salvaged wood from deconstructed military buildings (Davis, 2012). So far, there is support from the Forest Products Association of Canada for the usage of reclaimed lumber, but, overall, there is no research specific to the structural application (Ergun, 2014).

As discussed in section 5.3, there are no current grading rules for stress grading reused wood, either by machine or visually. These rules would need to be established if wood is to be reused structurally." (BFM Ltd, BRE Ltd, 2004, p. 91). Therefore, "wood used in load-bearing applications must be pre-approved by [the project engineer and also] local building inspector."

This current system for regrading lumber is very time consuming, costly, and inefficient. Most of the time for visual regrading of lumber, the grade is considered one degree lower than that of freshly sawn lumber as a result of damage. However, some of these damages may have no effect on the structural integrity of lumber. Therefore, there is a need for developing standard methods for regrading lumber. Therefore, regraders are able to stamp large quantities of salvaged lumber.

There are some studies in the literature that have suggested grading methods for historic structures (Anthony, Dugan, & Anthony, 2009) or conducted visual and physical studies on the structural integrity of salvaged lumber (Davis, 2012, pp. 17-25; Chini & Acquaye, 2001; Falk, Maul, Cramer, Evans, & Herian, 2008; Falk R. H., 1999).

The study of Falk, Maul, Cramer, Evans, and Herian (2008) tested over 1000 pieces of 2×6 (10 foot), 2×8 (12 foot), and 2×10 (14 foot) from four different locations and building types in the US. All the tested buildings were built in the early 1940s and the lumbers were used as studs, floor and roof joists, stringers, and rafters. The woods were visually graded as Select Structural (SS) or No.2. Over 90% of the lumber collected was Douglas Fir. The bending strength of salvaged lumber was about 25% lower than new lumber. Mean stiffness was about 10% higher. Nail hole affected the strength when they were closely spaced or created further splitting, especially when they were located at the high-stress tension edge (Falk, Maul, Cramer, Evans, & Herian, 2008).

Table 4 Current price comparison of salvaged and new lumber

Size of lumber	Price (CAD /ft)					
	Salvaged Not-processed grade[12]	Salvaged De-nailed Utility grade[13]	New Small quantities[14]		New Large quantities[15]	
Grades	Utility	Utility	No.2 (Fir KD 12")	No.2 (Spruce 12")	No.2 (Fir KD 12")	No.2 (Spruce 12")
2×4	0.15-0.20	0.25-0.30	0.40	0.35	0.3	0.27
2×6	0.25	0.30-0.40	0.65	0.55	0.50	0.43
2×8	0.25-0.30	0.40-0.50	0.80	0.77	0.67	0.66
2×10	0.50-0.65	0.65-0.90	1.20	1.10	0.90	0.87
2×12	0.85-1.00	1.00- 1.30	1.5	1.60	1.30	1.40

Labor cost[16]:

- De-nailing: 10-12$/hour
- Deconstruction: 15-20$/hour
- Supervisor: 15-20$/hour

7. What the City of Vancouver and other governmental organizations and can do?

The focus of this study was not much on what public sector (such as the City of Vancouver) can do to encourage and/or facilitate framing lumber reuse. It was rather on the opportunities for framing lumber reuse in the current market situation. However, to advance lumber reuse to its fullest potential, it is necessary that the public sector take some initiatives to incentivize material reuse. The following are the most important suggestions for the public sector to help improve salvaged lumber reuse:

- Mandating audits or inventories of salvageable materials in all the public projects and a percentage of salvaging (with green jobs training) to secure the availability of salvaged materials in the market and support the development of deconstruction industry (Earle, Ergun, & Gorgolewski, 2014, p. 24; Delta Institute, 2012, p. 15; Kane Consulting, 2012)

[12] Prices are asked from Dave Bennink, RE-USE Consulting. The prices were originally stated in the USD and then transferred to CAD.

[14] Dick's Lumber
[15] Dick's Lumber
[16] Dave Bennink, RE-USE Consulting

- If the COV has the resources, it can fund deconstruction and reuse businesses. "The City of Chicago and Cook County are examples of local governments that are currently using government grants to subsidize deconstruction work, provide examples, and build capacity and jumpstart the local market." (Delta Institute, 2012)

- Passing ordinances that require private demolition contractors to salvage a specific percentage of materials. This can be incentivized by factors such as giving re-zoning permit, precipitated permit processes, etc. (City of Vancouver, 2014c, pp. 11,12). Minimum reuse requirement has been implemented in some other jurisdictions such as Cook County, IL and Seattle, WA (City of Vancouver, 2014c, p. 4)

- Provide educational document and resources in a specific web page and through educational workshops. Example of educational webpage is the City of Portland reuse page (Delta Institute, 2012, p. 16).

- Announce best practice projects publicly through social media and COV webpage, to make reuse visible and marketable

- Support the development of a Reuse Centre, which ideally provides all the services related to material salvaging. This includes collecting (pick-up), storing, processing, remanufacturing, and retailing of salvaged or upcycled products (City of Vancouver, 2014c, p. 14; Dovetail Partners, 2013, p. 114). Examples of such central reuse facilities are the Chicago's Rebuilding Exchange enterprise and the ReBuilding Center in Portland.

  One of the challenges for supporting a Reuse Centre is the high price of real estate in the region, which creates doubt in the economic feasibility of having such a centre. A potential solution is that the City of Vancouver uses the temporarily vacant public lands to sort, store, and possibly process salvaged wood. Another option is that the City incentivizes private land owners to rent their land for this purpose if they are not developing the land for a certain period of time. Areas such as Cambie Corridor, where many lots are vacant due to the fast redevelopment plans, can be good candidate for piloting the use of temporary vacant private lands for the Reuse Centre.

- Support the development of a virtual inventory of available salvaged wood from individuals, businesses and soon to be demolished building. COV can mandate all the buildings that apply for demolition permit to post the estimated salvageable lumber in their projects, if they are not planning to salvage it themselves, sometime ahead of demolition.

- Encourage and support the authorities (NLGA and CWC) to develop a standardized and generic grading rules and engineering property data, suggested reuse option for each grade, and propose a grade stamp for salvaged lumber (Delta Institute, 2012, p. 46). This can be done through a limited repetition of component tests on salvaged lumber in laboratories (Falk, Maul, Cramer, Evans, & Herian, 2008). Establishing a grading method will facilitate the grading process so that graders are able to visually regrade salvaged lumber for structural use in large quantities. This will reduce the cost of grading process.

- Support creating a standard stamp that specifies salvaged wood components with a short story about their past life. This will help the reuse efforts become more visible and attractive for the green businesses.

- Considering the fact that not all wood in old buildings is salvageable, it is important to consider other upcycled alternative. In the UK, panel board mills (plywood, OSB, particleboard) are oldest and biggest customers of the use of recycled wood. Other alternatives for recycled wood (chips) in the UK include: biomass, animal bedding, and land applications such as landscaping (BFM Ltd, BRE Ltd, 2004; Dovetail Partners, 2013). “In Canada, not enough is understood of the treatment options to facilitate recycling or reuse of [waste] wood.” (Earle, Ergun, & Gorgolewski, 2014). Therefore, governments, forest product manufacturers and organizations should support the research on engineered wood and up-cycled wood products from salvaged lumber[17].

- Support research on equipment and technologies for framing lumber salvaging. This may include technologies for faster deconstruction of the building, de-nailing of salvaged wood, and tools that make working with hard and dried old wood easier.

- Set up an idea competition among professionals and students and show case exhibition of creative marketable structural and non-structural designs with salvaged wood

- It is also crucial that the authorities set requirements and incentives for designing for future deconstruction for new buildings. It is discussed in the literature that newer building use materials (such as composite wood) and adhesives that makes reuse or recycling difficult or impossible (Falk R. , 2002).

[17] Metro Vancouver is collaborating with Centre for Advanced Wood Products at UBC to identify opportunities for using clean wood waste in engineered or up-cycle products (please see the interview with Nermine Tawfik, Technical Advisor, Metro Vancouver

Iain Macdonald, Managing Director, Centre for Advanced Wood Processing, UBC

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Appendices

A. *List of businesses that use salvaged dimensional lumber*

Table 5 List of businesses that use salvaged dimensional lumber

Company/ Organization	Services with salvaged lumber					Location	Contact			Notes
	Dimensional lumber sale	Furniture	Flooring	Interior	Construction		Email	Phone/Cell	Website	
Vancouver Timber	?*	◙	◙			Coquitlam	Email	P: 604.925.4597 C: 604.202.1032	Link	Karl Simmerling
J&S Reclaimed Wood		◙		◙		Vancouver	Email	P: 778-317-3027	Link	
Union Wood Co.		◙		◙		Vancouver	Email	P: 604.675.9033	Link	Craig Pearce
Vancouver Reclaimed		◙		◙		Vancouver	Email	C: 778 228 6617	Link	Brooke Wingrove
Wood-shop worker's co-op		◙		◙		Vancouver	Email	C: 778 899 5353	Link	Use salvaged wood from buildings (including 2×4)
Hobo Woodworks		◙		◙		Vancouver	Email	C: 604 250 2691 or 778 709 3043	Link	Urban reclaimed wood
Pacific Design Lab		◙				Vancouver	Email	C: 604-603-0722	Link	Use reclaimed and new (not necessarily reclaimed from buildings)
Hall It Up			◙	◙		Victoria	Email	C: 250.881.4809	Link	Salvaged wood from homes
Canadian Heritage Timber Company	◙	◙ *limited*	◙	◙ *limited*		Chilliwack	Email	P: 604.392.9298	Link	Salvaged wood from warehouses
Jacks New & Used Building Materials			◙			Vancouver	Email	C: 778 899 5353	Link	Siding and flooring, not from dimensional lumber
Barn House	◙					Abbotsford	Email	P: 604 617-2999	Link	Barn boards 6-12" wide, 3/4 to 1" thick, and in lengths from 6-16'

Company/ Organization	Services with salvaged lumber					Location	Contact			Notes
	Dimensional lumber sale	Furniture	Flooring	Interior	Construction		Email	Phone/Cell	Website	
Urban Barn		◙				Vancouver			Link	*Multiple locations*
Habitat ReStore	◙?					Vancouver		P: 604-326-3055	Link	- Deconstruction services Stores also in Burnaby and North Vancouver
Western Reclaimed Timber	◙ Cut from large salvaged timber		◙			Maple Ridge	Email	P: (604) 263-2510	Link	Salvaged wood from barns, mills, and large buildings
Naturally Crafted Construction	?	◙		◙	◙	North Vancouver	-	C: 778-996-4011 or 778-899-7310	Link	Use salvaged wood from buildings (including 2×4)
Peter Fenger Builders					◙	Vancouver	Email	P: (604) 263-2510	Link	Custom doors, windows, & moulding *Adam Steinberg (BASK Development) suggested them*
Willow Creek Builders	◙	◙	◙	◙	◙ Renovation	Campbell River, Vancouver Island	Email	P: 250.923.7174 C: 250.202.7170	Link	Salvaged wood from barns and mills

** I have not directly contacted them, to ensure they sell salvaged framing lumber from house deconstructions*

*** Also check the following website for updates on the salvaged dimensional lumber retailers:*
www.metrovancouverrecycles.org
http://vancouver.reuses.com/

A.1 Online resources

Salvaged dimensional lumber may also be found in the following community trade websites:
http://www.kijiji.ca/
http:// craigslist.ca/

B. *A rough estimation of framing lumber used in pre-1940s houses in Vancouver*

❖ ***Existing quantity***

- ***Assumptions:***

  ○ ***Houses average size***

Average total floor area: 2061 sqft
(based on the average floor area of 110 samples of pre-1940 houses[18])

  ○ ***Average area of each floor***

Average first floor area: 988 sqft
Average second floor area: 408 sqft Second Floor Area=0.41×First Floor Area
Average basement area: 565 sqft Basement Finish Area=0.57×First Floor Area
(based on the average floor area of 44 samples of pre-1940 houses (Wegner, et al., 2015))

Average Total floor area = Average first floor area + Average second floor area + Average basement area → 2061 sqft = first floor area (1+0.41+0.57)
Average First Floor Area: 1041 sqft
Average Second Floor Area: 427 sqft
Average Basement Finish Area: 593 sqft

  ○ ***Number of existing pre-1940s houses***

1900s: 1129
1910s: 7988
1920s: 9324
1930s: 4732
1940s: 9030
(Extracted from **Invalid source specified.**)

Pre-1930s: 18,441
1930s-1940s: 13,762
Total: 32,203

  ○ ***Number of houses demolished per year***

About 900-1200 Demolition permit is granted each year by the City of Vancouver, from which 40% are pre-1940 (City of Vancouver, 2014c)
= 360-480 houses

  ○ ***Hypothetical framing structure for pre-1940s houses***

[18] Pre-1940s Deconstruction Permit Tracking document, City of Vancouver (unpublished)

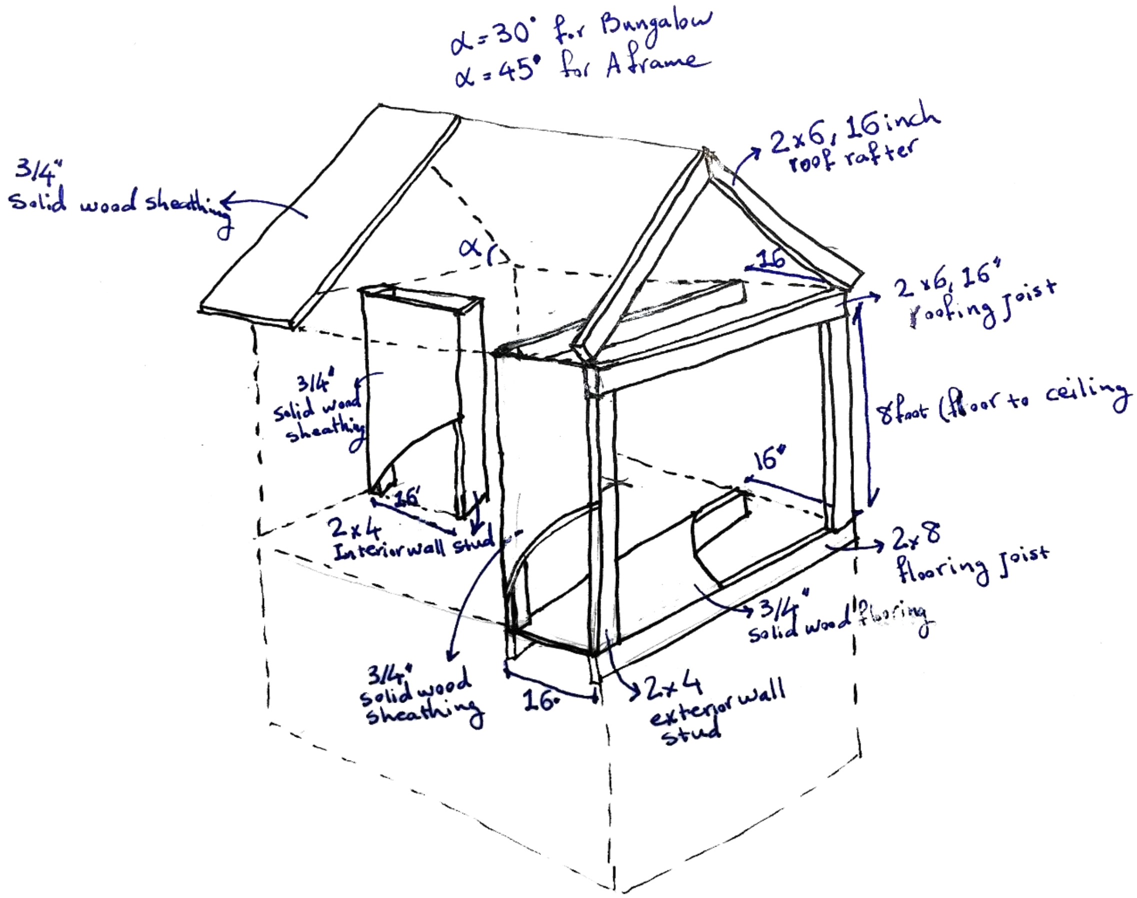

Figure 48The schematic drawing showing the framing dimensions assumed in the of the hypothetical house

The estimation has not included lumber used in functions such as window and door and some other miscellaneous functions in framing.

Although in larger houses 2×10 and 2×12 lumber is occasionally used, it is not included in this estimation, because these dimensions were not common in old houses.

- ***Estimating framing lumber in the hypothetical house[19]:***

❖ ***First Floor***

- ***Wall***

Exterior wall length= $4\times\sqrt{1041} = 4\times32.3 = 129$ ft
Interior wall length= Interior wall ratio (0.102979)×1041= 107 ft
2×4,8ft, each 16”: (129+107)/1.33=177 pieces

- ***Flooring***

2×8 each 16”: 32.3/1.33=24 pieces 32.3 feet long (the length is very inaccurate as it depends on buildings floor plans)

[19] The sizes, distances, and quantity of each size of lumber is based on the assessments in (Wegner, et al., 2015)

- ***Ceiling***

√ (1st floor sqft – 2nd floor sqft) /1.33 ft (16")

Flooring for the second floor is ceiling of first floor

2×6 each 16": √ (1041-427)/1.33 = 19 pieces 25 ft long

❖ ***Second Floor***

- ***Wall***

Exterior wall length= 4×√427 = 4×20.7 = 83 ft

Interior wall length= Interior wall ratio (0.108604) ×427= 46 ft

2×4,8ft, each 16": (83+46)/1.33=97 pieces

- ***Flooring***

2×8 each 16" : 20.7/1.33=16 pieces 20.7 feet long

- ***Ceiling***

2×6 each 16" : 20.7/1.33=16 pieces 20.7 feet long

❖ ***Basement***

- ***Wall***

Interior wall length= Interior wall ratio (0.099999)×593= 59 ft

2×4,8ft, each 16" : (59)/1.33=44 pieces

- ***Flooring***

Concrete

- ***Ceiling***

Flooring for the first floor is ceiling of basement

❖ ***Roof***

Roof ft^2 = 1st floor ft^2/cos (degree)

1041/cos ((30+45)/2)= 1312 ft^2

1312/2= 656 ft^2

Roof length= √656 = 26 ft

Rafters: 2×6 each 16" : 26/1.33=19×2= 38 pieces 26 feet long

❖ ***Total***

Pre-1930s houses (full dimension lumber):

2×4: (177+97+44) ×(2×4×96) (8 foot) = 318×768 = 244,224 in^3 = **4.00 m^3**

2×6:

first floor: 19×(300×2×6) = 68,400 in^3

second floor: 16×(248.4×2×6) = 47,693 in^3

Roof rafters: 38×(312×2×6) = 142,272in^3

= 258,365 in^3 = **4.2 m^3**

2×8:
first floor: 24×(387.6×2×8) = 148,838 in^3
second floor: 16×(248.4×2×8) = 63,591 in^3
= 212,429 in^3 = **3.48 m^3**

Total: 11.68 m^3 : 11.68×415 = 4,847 kg
(1 m^3 Compacted dimensional lumber ≈ 415 kg (University of British Columbia, 2015)*)*

1930-1940s houses:
2×4: (177+97+44) ×(1.5×3.5×96) (8 foot) = 318×504= 160,272 in^3 = **2.63 m^3**

2×6:
first floor: 19×(300×1.5×5.5) = 47,025 in^3
second floor: 16×(248.4×1.5×5.5) = 32,789 in^3
Roof rafters: 38×(312×1.5×5.5) = 97,812 in^3
= 177,626 in^3 = **2.91 m^3**

2×8:
first floor: 24×(387.6×1.5×7.5) = 104,652 in^3
second floor: 16×(248.4×1.5×7.5) = 44,712 in^3
= 149,364 in^3 = **2.45 m^3**
Total: 7.99 m^3 : 7.99×415= 3,316 kg

Total estimated framing lumber in all the existing pre-1940s houses in Vancouver

Pre-1930s houses (full dimension):
2×4: 4.00×18,441= 73,764 m^3
2×6: 4.2×18,441= 77,452 m^3
2×8: 3.48×18,441= 64,175 m^3
Total: 215,391 m^3

1930-1940s houses:
2×4: 2.63×13,762= 36,194 m^3
2×6: 2.91×13,762= 40,047 m^3
2×8: 2.45×13,762= 33,717 m^3
Total: 109,958m^3

Total: 325,349 m^3 (×415 kg/m^3) = 135,020 tonnes

Total estimated framing lumber in pre-194s houses demolished per year

Pre-1930s houses (full dimension):
Number of houses: (18,441/32,203)×360 to 480 = 206 to 275
2×4: 4.00×(206 to 275) = 824-1,100 m^3
2×6: 4.2×(206 to 275) = 865-1,155 m^3

2×8: 3.48×(206 to 275) = 717-957 m^3
Total: 2,406-3,212 m^3

1930-1940s houses:
Number of houses: 360 -206=154, 480-275=205: 154 to 205
2×4: 2.63 (154 to 205) = 405-539 m^3
2×6: 2.91×(154 to 205) = 448-597 m^3
2×8: 2.45×(154 to 205) = 377-502 m^3
Total: 1,230-1,638 m^3

Total: 3,636 -4,850 m^3 (×415 kg/m^3) = 1,508 -2,013 tonnes/year

❖ ***Salvageable portion***

An estimation of reusable Framing Wood in all the existing pre-1940s houses in Vancouver

- ***Assumptions:***

  - ***Average reusable percentage of framing lumber[20]***

(A portion of lumber is not salvageable, due to the damages during deconstruction, de-nailing, or processing)
- Wall studs (2×4): 50-60%
- Rafters (2×6): 90%
- Flooring and ceiling joist (2×8): 80-90%

Pre-1930s houses (full dimension):
2×4: 73,764 m3×55%= 40,570 m^3
2×6: 77,452 m3×90%= 69,707 m^3
2×8: 64,175 m3×85%= 54,548 m^3
Total: 164,825 m3

1930-1940s houses:
2×4: 36,194 m3×55%= 19,906 m^3
2×6: 40,047 m3×90%= 36,042 m^3
2×8: 33,717 m3×85%= 28,659 m^3
Total: 84,608 m^3

Total: 249,433 m^3 (76.6% of total) (×415 kg/m^3) = 103,515 tonnes
This is comparable to existing Canadian literature estimating that 75% of demolition waste can be reclaimed (Ergun, 2014)

Total Estimated Framing Wood in pre-194s houses demolished per year
Pre-1930s houses (full dimension):
2×4: 824-1,100 m^3×55%= 453-605 m^3
2×6: 865-1155 m^3×90%= 778-1039 m^3
2×8: 717-957 m^3×85%= 609-813 m^3

[20] *Based on Dave Bennink (deconstruction expert) estimations*

Total: 1,841-2458 m^3

1930-1940s houses:
2×4: 405-539 m3×55%= 223-296 m^3
2×6: 448-597 m3×90%= 403-537 m^3
2×8: 377-502 m3×85%= 320-427 m^3
Total: 946-1260 m^3

Total: 2,787-3,718 m^3 = (×415/1000) 1,157-1,543 tonnes

This amount is only about 1% of total wood waste that City of Vancouver send to landfill:

City of Vancouver wood waste in 2013 = 1,400,000 (Metro Vancouver) × 0.3 (COV)* × 0.36 (wood)** = 151,200 tonnes

* City of Vancouver generated 30% of the waste generated in Metro Vancouver (City of Vancouver, 2014c, p. 6)
** Wood constitute 36% of the CRD waste generated in Metro Vancouver (Kane Consulting, 2012, p. 5)

C. List of interviewees

- ***Nermine Tawfik**, Technical Advisor, Metro Vancouver*
- ***Iain Macdonald**, Managing Director, Centre for Advanced Wood Processing, UBC*
- ***Felix Böck**, PhD Candidate, Centre for Advanced Wood Processing, UBC*
- ***Esther Berube**, Senior Project Engineer, Metro Vancouver*
- ***Greg Johnson**, Senior Instructor, Architecture and Civil Engineering, UBC*
- ***Mark Roozbahani**, Inspections assistant director, City of Vancouver*
- ***Jamie Steen**, District Building Inspector, City of Vancouver*
- ***Mark Gorgolewski**, Professor at the Department of Architectural Science, Ryerson University*
- ***John Leahy,** Canadian Mill Services Association*
- ***Allan Rozek** , National Lumber Grades Authority*
- ***Kevin Rocchi on behalf of Robert Jonkman**, Canadian Wood Council*
- ***Adam Cornel**, Naturally crafted construction*
- ***Amika Scott** , Western Reclaimed Timber*
- ***Christina Radvak**, ReStore, Habitat for Humanity*
- ***Eileen Keenan**, Bing Thom Architects*
- ***Allan Hall,** Hall it up!*
- ***Peter Moonen,** Municipal Affairs and National Sustainability Manager, WOOD WORKS!, Program of the Canadian Wood Council*
- ***Gerry Humphreys**, Milestone Project Management: deconstruction group in Winnipeg which train disadvantage communities*
- ***Dave Bennink**, RE-USE Consulting, Deconstruction and salvaged material retailer*
- ***Sonya Zeitler Fletcher**, Vice President, Market Outreach, Forestry Innovation Investment*
- ***Shawn P. Wood,** Construction Waste Specialist, City of Portland Bureau of Planning and Sustainability*
- ***Ed Loney**, District Building Inspector, City of Vancouver*
- ***Adam Steinberg**, BASK Development, Heritage house renovation contractor*

Opportunities and Regulatory Barrier for the Reuse of Salvaged Dimensional Lumber from Pre-1940s Houses

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GREENEST CITY SCHOLAR 2015