



## Approaches to Mobile Home Deconstruction

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**A best practices guide for home and park owners, local and state government, and emergency planners**

**OVERVIEW:** Mobile homes provide an important opportunity for many low to moderate-income families to achieve the dream of home-ownership<sup>2</sup>. Nationwide, mobile homes represent over 7 % of residential housing; over 8 million homes<sup>1</sup>. However, as they deteriorate or are damaged, mobile homes also present substantial waste management challenges. Although the quality of mobile homes, now referred to as manufactured homes, have improved over time, older homes were typically manufactured to last only 20 to 50 years<sup>5,8,9</sup>. This is illustrated by the situation in Vermont, where almost a fifth of occupied mobile homes in mobile home parks are more than 40 years old<sup>4</sup>. Additionally, because *more than 30% of homes in parks are not anchored, and 20% of homes in parks are located in flood hazard zones*, mobile homes are disproportionately vulnerable to damage during natural disasters<sup>8,10,11</sup>. For homes that have reached the end of their useful life, the volume and composition of the material in a mobile home makes disposal very costly. As a result, many are abandoned, which can be an environmental and health hazard if not managed properly. This research brief summarizes the findings from several studies in Vermont on the potential to reduce waste, hazards, and cost of damaged or aged-out mobile homes through several approaches to deconstruction and recycling.

### HOW MOBILE HOMES BECOME WASTE:

**Aging-out and abandonment:** While the quality of mobile home manufacturing has improved over the years and is expected to increase the structures useful life, there are still many homes in use that pre-date these improvements. Research done by the University of Vermont (UVM) found that over a fifth of the mobile homes surveyed in parks around the state were built before the 1976 U.S. Department of Housing and Urban Development (HUD) safety and construction standards for mobile home manufacturing were established<sup>4,8</sup>. The U.S. Census Bureau indicates that nationally, 1.5 million homes pre-date the HUD standards<sup>1</sup>. End-of-life disposal costs vary depending on the size of the home, furnishing and fixtures remaining in the home, distance to the landfill, and landfill costs. In Vermont, disposal costs ranged from

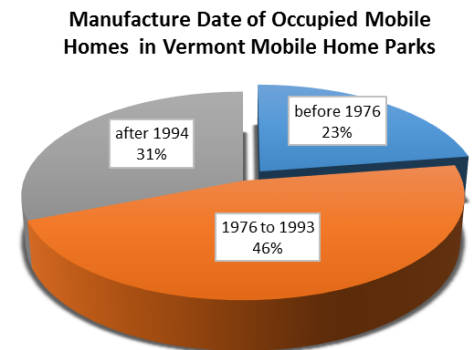


Figure 1. Age of occupied mobile home in Vermont in 2011<sup>4</sup>. (n = 248)



## The University of Vermont

\$2000 and \$6000 per home<sup>4</sup>. In Vermont, 74% of mobile home residents in parks had incomes at or below the 2010 HUD limits for low income, making disposal a significant burden and often resulting in abandonment of the structure<sup>10</sup>.

### Move before Aging out? Natural disasters:

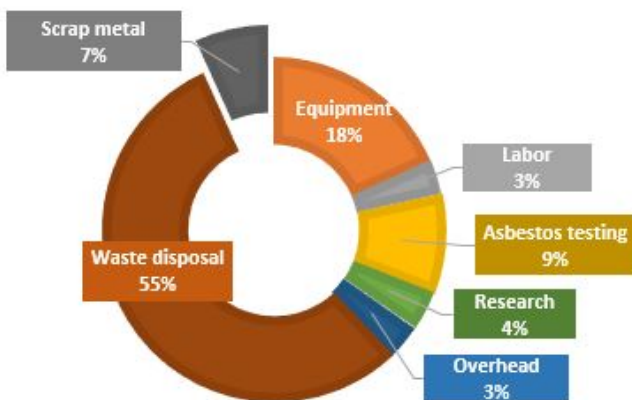
Another significant source of mobile home waste results from natural disasters such as floods, wind events, fires, and earthquakes. In Vermont, mobile homes represented 15% of all homes damaged by Tropical Storm Irene<sup>8</sup>. Analysis using geographical information system (GIS) map overlays of Vermont mobile home parks revealed that these parks were more than twice as likely to be located in a flood hazard zone as a traditional single family home<sup>8</sup>. A nationwide study in 2009 determined that 48 % of all tornado-related fatalities in the U.S. from 1996 to 2007 were in mobile homes<sup>11</sup>. In addition to the human suffering faced by displaced families, these natural disasters also left many tons of mobile home waste in their wake.



Figure 2. Mobile home vulnerability to natural disasters. Statistically, mobile homes are more likely than traditional homes to be damaged during natural disasters<sup>8</sup>.

### CONSEQUENCES OF WASTE:

**Health and environmental hazards:** Similar to other older buildings in the U.S., older mobile homes often contain asbestos, lead, and other health and environmental hazards<sup>6</sup>. After Tropical Storm Irene, a UVM research team found that 23% of 68 homes contained asbestos, primarily in the linoleum flooring<sup>10</sup>. Other sources of hazardous material included mercury found in thermometers and fluorescent lamps, and the paints, stains, and other household chemicals left behind. An empty single-wide mobile home can weigh in the range of 5-6 tons while double-wide mobile homes can have even greater weights and volumes. These large abandoned structures are often filled with left behind waste material, making the sheer volume of demolition waste going to the landfill a significant environmental cost. <sup>4</sup>.



### DECONSTRUCTION INSTEAD OF DEMOLITION:

**Case studies:** Deconstruction is the process of systematically taking the mobile home apart with the intent of salvaging useable or recyclable pieces. Three case studies in Vermont measured costs of deconstruction, diversion rates and methods. Deconstruction costs and savings were largely dependent on the total weight of the mobile home, transport and landfill rates, and market value of reclaimed materials. Total mobile home weight varied due to the amount of waste left in the home, non-recyclable attached structures and outbuildings, and how intact the home was at the time of deconstruction.

Figure 3. **Distribution of mobile home deconstruction income and costs.** Cost and waste reduction from recycling scrap metal in a 68 home deconstruction project after Tropical Storm Irene.

# Vermont Mobile Home Park Research



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The average weight of a mobile home from the three studies was 10.5 tons. Waste diversion rates depended on total mobile home weight and deconstruction method, and averaged around 22 % (1.9 tons). Cost for deconstruction and waste disposal across the 82 mobile homes included in the three projects averaged \$1,706 per home. Additionally, average net savings from reclaimed materials for the three projects was \$201 per home.<sup>7,3,4</sup>

**Table 1. Details of deconstruction techniques and diversion rates for the three Vermont case studies<sup>3,4,8</sup>.**

DECONSTRUCTION CASE STUDIES IN VERMONT			
	Bristol, VT (1998)	Alburg, VT (2005)	Tropical Storm Irene, Statewide (2011)
Event	Local flooding event	Planned deconstruction of abandoned homes	Statewide flooding event
Number of homes	Five homes	Ten homes	Sixty eight homes
Deconstruction technique	Deconstruction done by hand – approximately 100 hours/home	Deconstruction primarily by excavator with “thumb” attachment, faster process	Deconstruction with heavy equipment and minimal manual labor, approximately 4 hours/home
Diversion rates	Diversion rates ranging from 20-37%, with an average of 29%	High diversion rates, up to 32%	Low diversion rates, average of 9.7%
Additional factors	Because mobile homes were already moved to the Bristol Landfill, the time taken to deconstruct was not critical and allowed for the lengthier process of 100 hours/home	Increased weight of homes from stored household garbage	Significant cost increase due to asbestos testing and abatement. High home weight and cost variation due to emergency response scenario, partial home remains, and high percentage of attached structures and outbuildings. High cost per home and low diversion rates, but total waste and cost savings significant due to project scale
Project funding source	FEMA & state community grant	Community project with donated resources	Federal Emergency Response Agency (FEMA)

**Table 2. Details of average costs, diversion rates, and savings for the three Vermont case studies<sup>3,4,8</sup>**

	Number of Homes	Average Home Weight (tons)	Average Waste Diverted per Home (tons)	Cumulative Average Waste Diverted ( % )	Average Cost Savings/Home	Average Home Deconstruction Cost	Total Project Cost Savings	Total Tons Diverted
Planned Deconstruction								
Alburg A (2005)	3	9.7	1.7	18.0%	\$229	\$1,781	\$688	5.0
Alburg B (2005)	7	4.9	1.6	32.1%	\$220	\$1,328	\$1,538	11.1
Disaster Response Deconstruction								
Bristol (1998)	5	6.0	1.7	29.0%	\$147	\$775	\$737	11.1
Tropical Storm Irene (2011)	68	--	--	9.7%	\$207	\$2,942	\$13,069	104.6
Average		6.9	1.6	22.2%	\$201	\$1,706		

*Note.* Alburg A represents homes with additional household garbage; Alburg B represents homes without additional household garbage.

These results support the conclusion that deconstruction diverts waste from landfills. These studies have shown that a combination of mechanical effort and manual labor is effective at balancing waste diversion and cost.<sup>4</sup> Deconstruction using large scale equipment is both cost-effective and less time consuming than manual deconstruction, however by including supplemental manual labor, greater diversion rates can be achieved and opportunities to recycle materials arise.<sup>4</sup> Deconstruction also aids in identification of hazardous material, particularly asbestos, mercury and lead. Although these discoveries can increase costs, it ensures compliance with the law and protection of the environment and public health.





## DECONSTRUCTION PLANNING AND PROCESS: Best practices learned from case studies.

**Project scope and analysis:** The most cost-effective opportunities for deconstruction are those projects that involve multiple homes so that economies of scale and processing efficiencies may be realized<sup>3</sup>. Pre-identification of recycling and reuse markets could increase quantity and value of materials diverted from disposal. Project budgets should include transportation, heavy equipment, and disposal costs. Community development grants, hazard mitigation grants, and donations of time and resources may be available to reduce overall project cost.

**Contractor selection:** Contractors have reported that deconstruction is not a difficult process with proper equipment and technique, although does require some finesse with an excavator that has a hydraulic thumb<sup>3</sup>. Using an excavator with a hydraulic thumb is imperative to be able to effectively and efficiently segregate waste types, as other equipment is often too crude for successful deconstruction. Employing an experienced operator, or allowing new contractors time to refine the technique, can be key in optimizing equipment, labor, and fuel costs<sup>3</sup>.

**Site analysis:** A thorough site analysis includes a recycling and reuse inventory of the home, an asbestos and hazardous waste assessment, evaluation of heavy equipment accessibility, an assessment of the structural integrity and mobility of the home, and consideration of where the deconstruction will occur. For projects with multiple homes, moving them to a central, easily accessible location could minimize heavy equipment costs, while maximizing home processing efficiency<sup>3</sup>.

**Permitting:** Obtain all required state and local permits, perform any necessary asbestos and hazardous waste abatement and have the home detached from any electrical, water, sewage, or fuel utilities before finalizing deconstruction dates.

### Equipment needed on-site for deconstruction:

- Tracked excavator with a hydraulic bucket thumb
- 10-30 cubic yard Roll-Off Containers (2 are ideal; 1 for waste, 1 for metal recyclables)
- Bucket loader for moving material and waste
- Chop saw, drills, and other power tools for manual tasks (Gas and battery-powered if no electricity is available on-site)
- Truck & trailer to transport equipment, dumpsters, separate metal and waste roll off containers, or the mobile home to deconstruction site, if needed.

**Deconstruction technique:** The most efficient means of deconstruction was shown to be the combination of manual and machine disassembly. Manual disassembly was time consuming (nearly 100 hours), and using only heavy machinery lowers diversion rates<sup>3,4</sup>. The following steps are best practices learned from the three projects. Typically, this technique can be completed in half a day with one full-time equipment operator, one laborer, and one part-time equipment operator/laborer<sup>3</sup>.



Figure 5. **Deconstruction of a mobile home.** A mid-size excavator with a bucket thumb can disassemble a typical home in less than four hours.



### BEFORE DECONSTRUCTION

- 1) Complete a mobile home recycling and reuse inventory, including all potential hazardous waste sources.
- 2) Conduct an asbestos survey and abatement.
- 3) Prior to the day of deconstruction, conduct a 'walk through' of mobile home and remove any easy to remove, non-metal recyclable or reusable items and/or materials.

### DURING DECONSTRUCTION

- 4) Remove any hazardous waste.
- 5) Disconnect and remove by hand any salvageable small pieces, such as windows, doors, electrical, and plumbing.
- 6) Disconnect any additions, such as stairs and decks.
- 7) Using the excavator, clear the workspace around the home, including removal of any exterior structures.
- 8) Position metal recycling dumpster and waste dumpster near mobile home in a location easily accessible by excavator, while keeping in mind proximity to power lines.
- 9) Deconstruct the home by working one end completely and then the other, alternating tasks to minimize time spend positioning the excavator around the home. Segregate all metals, e.g., window frames, plumbing fixtures, as deconstruction continues.
  - a. Use the bucket thumb to remove the roof.
  - b. Lift out appliances, water tanks, furnaces, and other large unattached pieces.
  - c. Use the bucket thumb to peel off the siding.
  - d. Crush and remove the interior structures
  - e. Strip the flooring off of the steel frame.
- 10) Once striped down to the steel frame, use a chop saw to cut the frame so it fits in the dumpsters.
- 11) Use the bucket loader to fill the dumpsters for disposal. It is helpful to have a person on the ground aiding collection or salvage of smaller pieces.
- 12) Clean up the remnants with the loader and level the site.

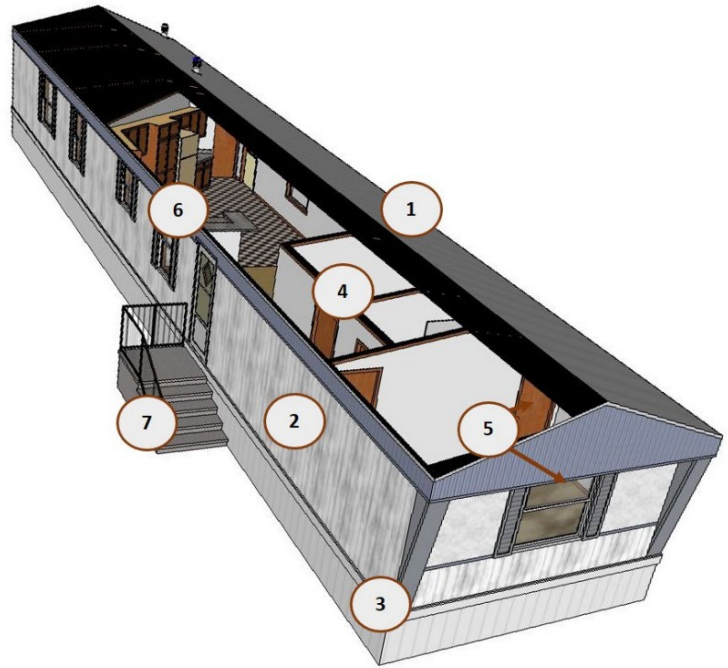


Figure 6. **Deconstruction of a mobile home.** A mid-size excavator with a bucket thumb can disassemble a typical home in less than four hours.

**Mobile home recycling:** There are many opportunities for recycling material from a mobile home structure, depending on current markets and interest in finding and/or developing new markets. The easiest to recycle and most valuable pieces are the metal roofing, siding, and in the chassis. Additional opportunities may exist in working with salvage yards and materials reuse organizations. In the long term, lobbying for revised mobile home manufacturing practices that consider serviceability, end-of-life disassembly, and regulations for hazardous materials may offer new and more cost-effective opportunities for recycling material.



1. **Roof**– metals (tin, aluminum, steel)
2. **Siding** – metals (tin, aluminum, steel)
3. **Skirting** – metals (tin, aluminum, steel)
4. **Framing and joists** – steel and wood framing from roof, floors and walls. Untreated wood can be salvaged for reuse or kindling, or burned on-site with proper permits.
5. **Windows and doors** – wood, metal, and glass can be recycled or reused, or they can be reused intact
6. **Appliances and fixtures** – sinks, bathtub, stoves, refrigerators, toilets, lighting, water tanks, pumps, and furnaces can be reused or recycled
7. **Constructs and outbuildings** – wood and metal stairs, decks, railings, sheds, and garages can be reused or recycled
8. **Electrical and plumbing** – copper pipes and wire can be recycled; components can be reused or recycled (not shown)
9. **Fuel tanks** – reuse or recycle (not shown)
10. **Chassis and axels**- reuse or recycle (not shown)
11. **Garbage and hazardous waste** – proper disposal of asbestos, lead paint, mercury thermometers, old fuel, household chemicals, and food products (not shown)



**CONCLUSION:** With planned deconstruction, waste diversion rates of 32% are reliably achievable, compared to only 10% in emergency situations. Cost of the disposal was reduced in either case by about \$200/home, but varies depending on transport and landfill fees, additional household waste, and available markets for recycled material. Both diversion rate and cost savings quickly becomes significant for larger projects. Anticipating deconstruction before disasters occur, or before the age of the mobile home makes moving it difficult, is critical to reduce costs and increase diversion rates. In addition, planning for mobile home deconstruction and proactively replacing outdated and dangerous homes can contribute to the overall resiliency of this important source of affordable housing.

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