

A FEASIBILITY STUDY OF MOBILE HOME RECYCLING

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Abstract

A June 1998 flood of the New Haven River destroyed Palmer's Trailer Court in Bristol, Vermont. As an offshoot of remediation of the property, a study of the techniques and feasibility of dismantling and recycling as much as feasible from a number of the damaged homes was performed. The study was a cooperative effort involving the Town of Bristol, the Vermont Agency of Natural Resources, and the Manufactured Housing Institute.

Background research on any similar mobile home salvage and recycling efforts indicated that interest is high, but that well documented research in the field is very limited. Relevant programs have been performed or are ongoing in Wisconsin, Michigan, North Carolina, and Vermont.

Estimates of the number of functionally-obsolete mobile homes in Vermont range from 12,000 - 15,000, representing a large quantity of waste - or resources - to be managed in the near future.

For the project, ultimately, five mobile homes were transported to the Town of Bristol Landfill, and a contractor was selected to "deconstruct" the homes in a controlled manner. The components of each mobile home were segregated into various categories, and materials of each category were documented and weighed. Depending on the material, a component was then either recycled, salvaged, burned, or landfilled. The time required to perform each task was also recorded.

Once the physical deconstruction was complete, the information that was collected was refined and evaluated. Based on the data, from 20% to 37% by weight of the mobile homes were salvaged or recycled, with the balance having to be landfilled or burned as clean wood. Each mobile home required from 79 to 97 person-hours to dismantle. The verifiable gross cost of the project was \$4613.60, the revenues from the reusable and recyclable items was \$736.55, and therefore, the net cost was \$3877.05, or \$775.41 per mobile home.

Mobile home deconstruction is possible and is being performed on a limited scale in Vermont and in other states. As are most recycling programs, mobile home deconstruction will not currently be profitable, but neither is it overwhelmingly expensive. It is an environmentally sound waste management practice that should be encouraged. Widespread salvaging of mobile homes would enhance blighted areas, conserve natural resources, preserve landfill space, create a legitimate option to mismanagement, abandonment or illegal disposal, and provide jobs and economic opportunity.

Introduction

On the night of June 26 - 27, 1998, a series of powerful thunderstorms swept through central Vermont. Particularly hard hit was a narrow band of land encompassing the New Haven River watershed to the east of the spine of the Green Mountains, and the Mad River watershed just over the mountains to the west. In South Lincoln, Vermont, over four inches of rain fell, much of that in just a few hours.

The New Haven River runs through the town of Bristol, Vermont. The June 1998 thunderstorms caused 100 to 500-year flood levels in the river, and as a result, many riverside properties were destroyed or damaged, and bridges, culverts, and entire roads were washed out. In essence, the town and its landscape were changed forever.

One of the casualties of the flood in Bristol was Palmer's Trailer Court. The trailer court was actually comprised of 11 individually-owned properties, containing a mix of mobile homes, framed houses, and outbuildings, located in the flood plain of the New Haven River about three miles south of Bristol Village. High springtime flows of the nearby New Haven had periodically been a nuisance, but the 1998 flood toppled over trailers, pushed houses off their foundations, and swept smaller personal effects away. Fortunately, all residents escaped without injury. Re-inhabiting the dwellings, or even rebuilding in that flood prone location, was out of the question.

In the aftermath, the Town of Bristol applied for, and received over \$500,000 in grant funds from the Federal Emergency Management Agency (FEMA) and the Vermont Agency of Commerce and Community Development (VACCD). The grant money was utilized to buy the individual trailer court properties, demolish and remove the dwellings and associated debris, then perform minimal site work to create a natural recreational area for the public's use. The building demolition and removal, and site restoration work was completed in the spring and summer of 1999.

Bristol is one of the few remaining small Vermont towns that continue to own and operate a municipal landfill. The landfill is permitted to accept a maximum of 1000 tons of waste per year. The Town initially contacted the Vermont Agency of Natural Resources (ANR) only for permission to exceed the 1000 tons per year cap, by allowing for the disposal of the mobile homes and other debris from the trailer court at the landfill. In the course of the dialog, the Town and Agency began to develop the idea of a study of the practicality of recycling the uninhabitable mobile homes. The Town was interested in diverting as much waste as they can from their landfill in order to prolong its lifespan, and the ANR is always eager to promote waste reduction and environmentally sound solid waste management practices.

While performing preliminary research on the project, ANR staff contacted the Manufactured Housing Institute in Arlington, Virginia. The MHI is the national trade organization representing all segments of the manufactured housing industry, and actively supports responsible management of obsolete mobile homes. MHI joined the ANR and Town of Bristol as the third partner in the project team, providing technical and financial support.

Principle team members were: Carolyn Grodinsky, Recycling Specialist, and James Surwilo, Environmental Analyst, ANR; A. Scott Powell, District Coordinator, and Robert Hall, Manager, Town of Bristol; and Eric Alexander, Manager, Land Use Activities, MHI.

The mobile home recycling project scope of work consisted of:

1. A literature review on the state of the practice of mobile home salvage and recycling.
2. Transporting a number of trailers from Palmer's Trailer Court to the Town of Bristol Landfill.
3. Soliciting bids, selecting a deconstruction contractor, and grant administration.
4. Deconstructing the mobile homes, segregating and weighing reusable, recyclable and disposable components of each home. Tracking weights, time, equipment and labor.
5. Project management and data collection.
6. Refinement of data, report writing, and communicating the results.

The objective of the mobile home recycling project is to provide real, unbiased data to allow for informed decision-making on the feasibility of mobile home recycling. With encouraging conclusions, environmentally sound waste management practices could be advocated. Widespread salvaging of mobile homes would save natural resources, conserve landfill space, create a legitimate option to abandonment or illegal disposal, and provide jobs and economic opportunity.

Background and Framework

Before fully committing to the project, the ANR reviewed the available research on the mobile home industry in general, waste management of mobile homes, and the subject of “deconstruction,” salvaging, and recycling of older mobile homes. The research included obtaining any pertinent written reports, contacting industry groups (such as MHI), environmental organizations, “green” building advocates, state and local governments, in- and out-of-state landfill operators, and waste management firms.

In the course of the personal inquiries and literature review, it became acutely apparent that while interest in mobile home recycling was high on all levels, there has been little true research and experience in the field. It is generally thought that the majority of mobile homes that reach the end of their useful life as primary housing stock are then converted to secondary uses such as hunting camps and storage sheds. At some point in time, either due to the deterioration of the mobile home, or change in land usage, or simply the owners desire, every older home will become dispensable and will need to be disposed of. What happens to the mobile homes when they become completely unusable is obviously situation dependent, and not very well documented. Many mobile homes, it is assumed, are simply crushed, transported to the nearest landfill, and disposed of as “construction and demolition debris.” Some obsolete mobile homes are simply abandoned in place, illegally disposed of in unauthorized dumpsites, or permanently “brought out to pasture.”

From Trailers to Mobile Homes to Manufactured Housing

What is now known as “manufactured housing” began as “trailer coaches” in the 1920s; crude and canvas-topped, they were pulled behind automobiles as American tourists first took to the roads. The use of trailers as long term housing exploded in the 1940s, initially as workers migrating to war effort-related jobs needed immediate housing, then for returning veterans seeking a toehold in home ownership. By the 1960s trailers had evolved into much larger “mobile homes,” and many took on the air of permanence with additional skirting, decks, and peaked roofs.

A watershed event for manufactured housing was the promulgation of the federal Manufactured Home Construction and Safety Standards (MHCSS), enforced by the Department of Housing and Urban Development, which became effective on June 15, 1976. [1] The “HUD code” provided uniform design and construction standards for factory manufactured homes, and led to industry-wide, significant improvement in quality, safety, aesthetics, and energy efficiency. A factory-built home produced prior to June 15, 1976, is commonly referred to as a mobile home or a pre-HUD Code home, while those built after adoption of standards are referred to as manufactured housing. “Modular”, “panelized”, or “pre-cut” homes are also classes of factory-built houses, but these types of units do not need to meet the HUD code, only state and local building codes. Pre-HUD Code homes are now at least 25 years old and are reaching the point of obsolescence in increasing numbers. It is mobile homes of this earlier vintage which were the focus of this project.

Mobile Homes in Vermont

According to Vermont Department of Housing and Community Affairs (HCA) estimates, there are approximately 19,000 manufactured homes in Vermont. [2] The U.S. Census Bureau’s 1990 measure was somewhat higher, 22,702 manufactured homes, representing 8.4% of Vermont’s housing stock. [3] Determining the precise number of these homes that are of pre-HUD Code vintage would require a search through each individual town’s land records; not practical given the goals of this project. Knowledgeable sources - the HCA, Champlain Valley Office of Economic Opportunity, and local manufactured housing dealers - believe that a reasonable assumption is that two-thirds of the total in Vermont, or about 12,000 to 15,000, are pre-HUD code mobile homes. These numbers obviously represent a huge potential volume of waste to be managed as these older home reach the end of their useful life, but also represent great opportunities for waste reduction, reuse, and recycling.

In Vermont, mobile homes are titled in a manner similar to vehicles. A change of ownership of a home requires the completion of a Vermont Mobile Home Uniform Bill of Sale. The form must be signed by the sellers and the town clerk of the town where the mobile home is located, and filed by the buyers with the town clerk of the town where the mobile home will be located after the sale. A Vermont Mobile Home Uniform Bill of Sale was completed and filed for each of the project trailers, with the Town of Bristol as the buyer.

Other Studies and Salvage Programs

Although few in number, several interesting mobile home salvage operations are on-going, or have recently occurred around the country. While the information available from these studies or on-going operations is useful, what was most notable from our research was the lack of reliable data that was generated, particularly on costs - or profits - and waste diversion, critical issues that need to be addressed before widespread mobile home recycling programs can be advocated.

In Scotland County, North Carolina, mobile homes which are condemned as unfit for habitation are brought to the county landfill for salvaging and disposal. Landfill employees remove the aluminum siding, wiring, steel frame, and other accessible metal items for their scrap value. No effort is made to salvage other components. According to County Engineer Jim Blackwell, it requires a three-person crew about one day to strip the mobile home of the salvageable metal. [4] The remainder is then crushed and landfilled. The homeowner is charged the \$29.00/ton standard tipping fee for construction and demolition waste for the entire trailer, and hence the trailer is weighed as it arrives at the facility. The county does not keep individual records on the weight or percentage of recycled material.

The Michigan Manufactured Housing Association is coordinating a mobile home salvaging operation for the Association's state member-dealers. [5] For a \$100.00 fee a dealer can bring an obsolete home, generally taken in trade, to "Ferrous Processing & Trading" in Detroit. Ferrous reduces the intact mobile home into approximate 12' section, and those sections are sent through a automobile shredder. Ferrous and non-ferrous metals are separated and collected, while the residual shredded waste is destined for the landfill, often being used as cover material. A typical 12' x 60' mobile home will produce about eight cubic yards of waste, and one or two cubic yards of scrap metal. The current value of the metals is \$200-\$400 which is compensation for waste disposal and other program costs.

"The Salvage King, Inc.," in Staley, North Carolina, is an established mobile home salvaging business. [6] For a \$600.00 fee, dealers and homeowners can drop off trailers at the facility, or transportation can be arranged at additional costs. Using a combination of heavy equipment and hand labor, aluminum and steel, lumber (if practical), and usable fixtures are removed, while the remainder of the mobile home is disposed of. No data has been made available on waste quantities, percentage diverted, and the like, but business has been strong in the last several years. The Salvage King has recently been awarded a grant from the State of North Carolina to assist in moving some of the deconstruction operations under cover.

In Vermont, mobile home salvaging is occurring at the Burgess Brothers, Inc., Construction and Demolition Waste Landfill in Bennington. [7] Burgess accepts about 20-25 obsolete mobile homes per year, charging a uniform \$500.00 per trailer tipping fee. The homes are roughly dismantled with heavy equipment, then metals are removed both mechanically and by hand labor. Burgess removes the aluminum siding, metal roofing, frame, appliances, and copper plumbing from the trailers for recycling. Useable bathroom fixtures, furnaces, windows and doors, and cabinets are removed for resale. Specific records of material quantities are not kept, nor is economic data. Burgess Brothers simply believes that recyclable and reusable materials should not take up valuable space in their landfill.

Project Start-Up

The project team met or communicated several times in early 1999 to detail the scope of work and budget for the project.

The team agreed that the proximity of the Bristol Landfill to Palmer's Trailer Court represented an ideal situation. The landfill afforded convenient access to a truck scale, scrap metal and wood waste piles, recycling area, town garage and equipment, and, of course, a disposal area for the non-salvageable material. The subject trailers could be transported to the facility, stored and deconstructed in - what was believed to be - a secure location.

It was agreed that a professional contractor would be hired to dismantle the mobile homes. The Town did not have the supplementary manpower within its public works department to be devoted as the labor for the project. Vocational education students, or first time offenders required to do community service were considered, but the team was concerned about liability, and there was joint concern that with a lack of supervision from the project team we would be "getting what we paid for". If this is to be a pilot project, it should be as representative as possible, and it was agreed that meant capable, motivated workers that could work independently.

The selected contractor would be required to dismantle the mobile homes into their various reusable, recyclable, or disposable components. “Recyclable” components are those that can be reclaimed or processed into new raw materials or finished products. This grouping would include the siding, the frame, wiring, copper plumbing (if applicable), metal window frames, fixtures and other removable metal. “Reusable” components include easily salvageable structural lumber, fixtures, working appliances, doors, and other materials which are judged to have value as they are. Reusable and recyclable components taken together are termed as “salvaged” components. The remainder of the home would be separated into various categories of materials so as to quantify the composition of a typical mobile home. The disposable components would include: roofing, insulation, composition wood (plywood, paneling, laminates), clean untreated wood, flooring, plastic, drywall, ceiling tile, and any other waste stream we believe to be a significant fraction of the total. Each category of segregated recyclable or reusable material or waste would be weighed prior to removal off-site or disposal in the landfill. The final categorizing would be made with input from the contractor, once that selection was made.

At the time of the 1998 flood, Palmer’s Trailer Court contained nine mobile homes. Based on a post-flood inspection it was believed that five were transportable by convention mobile home moving techniques, while two or three others potentially could be moved on a “low boy” trailer if necessary. The project team felt that five was the minimal number for a representative sampling of pre-HUD Code homes, to determine if the proportions of components and work effort involved differed from trailer to trailer. A larger number of homes was also desired to allow for the possibility of attempting different deconstruction techniques on individual trailers.

Unfortunately, when the process of moving the mobile homes from the Court to the Bristol Landfill began in July 1999, it was discovered that age and the flood had seriously impaired the structural integrity of more of the trailers than originally thought. Only two of the original nine trailers were deemed to be roadworthy. These two were transported to the landfill while the other six mobile homes were left at the Court to be disposed of with the remainder of the structures and debris.

With only two trailers available from Palmer’ Trailer Court, the project team canvassed the Addison County Community Trust and nearby mobile home park owners to acquire additional trailers to deconstruct. The preference was for homes from Bristol itself, and two were procured: one from the Maple Ridge Trailer Park, and one from the Roger Blaise trailer park. A third trailer was obtained in Starksboro, a town adjacent to Bristol. The owners of the homes were obligated for the cost of transportation to the landfill, for the reciprocal benefit of free disposal. By October 1999, all of the five needed mobile homes had been transported to an unused section of the Bristol Landfill.

A Request For Bids (RFB) was formulated and published in the Addison Independent and Burlington Free Press, and was sent to several contractors. With winter and difficult or impossible working conditions approaching, a compressed schedule was established. The RFB contained a December 1, 1999, completion date for the physical dismantling of the trailers. Disappointing to the team, no formal bids were received in response to the RFB. Two contractors that had previously expressed interest in the project were contacted and both restated their desire to perform the work. Both contractors were invited to a site “walk-through” and interview, and

allowed to bid.

As a result of the process, the project team selected as the contractor David Sargent and Marie Wright, doing business as D & M Salvage and Recycling of East Burke, Vermont. D & M Salvage has been in the mobile home recycling business for approximately ten years and during that time have recycled an estimated 200 homes. With this experience they have developed a network of markets for reusable mobile home and building parts and accessories, scrap metal, and recyclable materials. The accepted bid price to perform the deconstruction was \$425.00 per mobile home, or \$2100.00 total. The contractors retained salvage rights to any material from the mobile homes once that material had been sorted, weighed and documented.

Based on the walk-through and subsequent discussions, the project team and contractors agreed that materials from the homes would be segregated into the following categories, as feasible:

- C aluminum
- C steel
- C other metals (copper, brass, "tin")
- C clean, untreated, unpainted wood
- C painted, treated, or composite wood (including laminates, plywood, and paneling)
- C gypsum drywall
- C insulation
- C flooring and rugs
- C reusable fixtures, appliances, and other items
- C miscellaneous

One of the primary considerations of the mobile home deconstruction project was to determine the overall quantity of material that older mobile homes are comprised of, and to determine if there is any consistency in the composition of mobile homes of the same vintage. Beyond a simple classification of waste types, the team was interested in learning how much of that waste could be diverted from disposal -- how much could be, or potentially could be, reused, recycled, or burned for energy? Since accurate weight records were important, the project team devised a "Weight Records" (Appendix A) sheet for D & M to allow for simplified and uniform documentation.

Weight records were kept for each load, and included information regarding the date, the type of material segregated, the trailer number from which the material was removed, and the final disposition of the material after weighing.

Another major goal of the project was to evaluate the resources; time, equipment, and money, which are needed to salvage “typical” older mobile homes. The level of effort required for a controlled deconstruction will be a primary consideration when deciding if this is a program worth performing on a permanent basis. If the economic data indicate that costs of an ongoing mobile home recycling program are unreasonable as compared to the quantity of waste diverted from disposal, the manufactured housing dealers, waste management entities, and mobile home owners themselves will not support such a program. There may be components of the trailer that are economically justifiable in salvaging, while other items are too time-consuming for their value. Given the importance of documenting the resources required to dismantle the homes, the project team provided D & M with “Daily Log” sheets (Appendix B) to record each days’s activities: how much time was spend on what trailer, by how many workers, performing what task.

Deconstruction of the Mobile Homes

The deconstruction phase of the project began inauspiciously. On the night of November 6, 1999, two days before the contractors were to begin their work, trespassers entered the landfill and accidentally or purposefully set one of the mobile homes on fire. The home burned quickly and completely, virtually leaving only the steel frame, fixtures, and ashes. The fire also seriously damaged the adjacent mobile home, to such a degree that it also could not be used in the study. Once again, the project team was forced to locate and arrange for additional trailers to be brought to the landfill.

While two additional trailers were being sought, on November 8, 1999, the contractors began dismantling the three remaining homes: “T-1”, “T-2”, and “T-3”. T-1 was the trailer from the Maple Ridge Trailer Park in Bristol, was manufactured by “Newport”, and measured 12' x 64'. T-2 was brought in from the Blaise Trailer Park, was of an unknown manufacturer, and measured 12' x 50'. T-3 was the only project trailer remaining from Palmer’s Trailer Court, was also of an unknown manufacturer, and measured 12' x 60'.

D & M generally worked 9:30 a.m. until dark, Saturday through Thursday, as the weather allowed. The typical crew consisted of two or three D & M employees, and occasionally a day laborer who was either compensated with pay or materials from the mobile homes.

The deconstruction work was primarily performed with hand tools in order to keep materials that had value intact, and for ease of documentation of the different types of material. A chain saw was utilized for cutting composites, such as the flooring/subflooring and other non-recyclable and non-reusable waste materials into manageable pieces. Rechargeable battery-powered drill/drivers were employed for various tasks. An acetylene torch was used to cut up the trailer frames. On occasion, the Town of Bristol’s bucket loader was requisitioned to move a trailer or frame, or to collapse a trailer that had been “guttled”.

On November 17, 1999, two replacements for the burned mobile homes were acquired and brought to the Bristol Landfill. The homes were provided by Brault's Mobile Homes, Inc., of Colchester, Vermont, a manufactured housing dealer, and both were taken in trade. Mark Brault considered trailer "T-4" to have little or no value, while trailer "T-5" potentially had a value of up to \$1000.00 as a hunting camp, storage shed, or other secondary use. The dimensions of T-4 were 14' x 70' and the home weighed 14,900 pounds intact. T-5 was also 14' x 70', and the home weighed 13,220 pounds. Because these two replacement homes were larger than the originals, and the interiors were remodeled and drywalled, D&M requested and received an additional \$425.00 (\$2525.00 in total) for their supplemental effort.

The deconstruction of each mobile home followed a similar pattern, which D & M believed to be the most efficient method of performing the work. First, any easily acquired, reusable or recyclable materials were removed from the interior of the mobile home. This would include any worthy furniture, appliances, carpeting, interior and exterior doors, sinks, toilets, bathtubs, cabinets, vanities, countertops, shelving, paneling, and trim. Also initially removed would be the furnace and electrical breaker box if resalable, and all lighting fixtures, electrical outlets and covers and miscellaneous hardware. Essentially, if an item had monetary value, or at least could be reused or given away, it was removed and set aside.

After salvage operations, the interior walls, comprised of either paneling or drywall, were removed, exposing the wall studs and insulation beneath.

Once the interior salvage and waste removal was complete, work began on the exterior. First all of the windows, and then the aluminum siding was removed, leaving the wooden studs and joists and wall insulation exposed on both the exterior and interior of the home. The studs were carefully removed until the trailer's ceiling and roof collapsed onto its floor. When available, the Town's bucket loader was utilized to safely complete this operation.

With the roof down onto the floor, workers would remove the sheet metal roofing for salvage, then remove the insulation underneath. Roofing joists would then be dismantled, and the lumber saved if reusable. In doing so, the tile or drywall ceiling would be detached and segregated as waste. At this point, the mobile home is reduced to only the flooring and subflooring, attached to the steel frame. All of the structure above the floor surface has been removed and relocated.

The flooring; carpet, vinyl, tile, wood, or whatever the individual rooms were comprised of, would be detached from the subfloor, if possible. Often, the flooring and subflooring (typically 3/4" plywood) were glued together, and sections would be cut with the chain saw, and carefully removed in order to salvage the floor joists. In turn, if competent, the 2" x 6" or 2" x 8" floor joists were unbolted from the steel frame, and disconnected from each other for salvage. Generally, the trailers were constructed with a sheet of fiberboard attached to the bottom of the floor joists, and with a thin layer of fiberglass insulation between each joist.

D & M brought a pick-up truck to the site on a daily basis. Materials of a specific type were loaded into the truck as deconstruction progressed. The loaded truck was then driven the 200 yards or so to the Bristol Landfill truck scale and the net weight of the load was calculated. Depending on the nature of the particular material, it was either:

- C retained by the contractor for future processing or resale;
- C sold immediately (as explained below);
- C brought to the nearby scrap metal dealer for the scrap value;
- C off-loaded in the scrap metal pile at the landfill
- C off-loaded in the clean wood burning site at the landfill; or
- C off-loaded in the active disposal area of the landfill.

Once underway, the project went very quickly and smoothly. Deconstruction began on November 8 and was completed on December 14, or about one trailer per week. For the time of the year, particularly in Vermont, the weather was cooperative. Only two or three days were lost because of inclement conditions.

Reuse and Recycling

As an integration of the project team's desire to divert as much waste from disposal as feasible, and D & M's knowledge and experience in the field, a pragmatic salvaging and recycling strategy was implemented. Items and materials that had economic value, or could be donated, bartered, or reused at a later date were segregated, if the amount of labor required to do so was reasonable. As a cost-benefit analysis could not practically be performed in every situation, D & M used their best judgement in determining what could be salvaged and what must be disposed.

Metal

In spite of currently depressed scrap metal prices, the economics justified recycling all non-ferrous metals to the extent that they could be practically separated from the waste. The exterior aluminum sheathing and aluminum window frames found on each of the trailers comprised the greatest quantity of non-ferrous metal by weight, and combined with its relatively high scrap value (\$0.20/lb.), resulted in aluminum being the most valuable commodity. Other non-ferrous metals collected included copper plumbing, brass fixtures, and copper electrical wiring. For this project, the copper wiring was loaded unstripped in "gaylords"; large, reusable, cardboard boxes affixed to wooden pallets.

Each of the mobile homes contained some quantity of light ferrous, predominately from the metal roofing, but also from ductwork, fixtures, and other miscellaneous items. Salvaging light ferrous scrap (“sheet metal” or “tin”) is economically questionable given the present market price of approximately \$15.00/ ton, delivered to the dealer. However, the Town of Bristol manages a scrap metal pile, and the pile is routinely processed and baled by a scrap metal dealer as part of their landfill and recycling operations. Because the existence of the Town’s metal pile afforded a convenient and economical recycling option, the light ferrous metal was deposited there.

All mobile home frames have economic value. Optimally, the steel framing members are in good structural condition and can be used to fabricate other products, and axles and wheels are functional for use on other trailers. If the components cannot be reused or recycled, the “heavy” steel is worth salvaging for its scrap value, in some instances if only to avoid a disposal cost. D & M normally pays a welder approximately \$150.00, depending on the size and condition of a frame, to cut the steel into manageable pieces that could be moved off site. The cost of the cutting is usually more than offset by the value of the components. For this particular project, D & M employed the services of Mr. Roy Hutchins, a experienced welder who also fabricates storage and utility trailers from mobile home frames. Mr. Hutchins was allowed to cut the frames, and keep the framing members, axles, and wheels (as well as some lumber, as noted below), in exchange for his part time assistance in deconstructing the trailers.

In the latter stages of the project, Mr. Hutchins brought to the site a utility trailer that he had fabricated from the frame of one the project trailers that had been burned. This particular utility trailer was a 20' long flatbed unit, fully road worthy, with equipped with a ball coupler, lights, and electric brakes. Mr. Hutchins can fabricate such trailers in about three days, and they sell for approximately \$800.00 each.

Wood

Some amount of dimensional lumber was salvaged from all of the project homes, ranging from an estimated 261 pounds from T-5, to an estimated 770 pounds from T-1. “Estimated” because the lumber was bartered or sold during the deconstruction process, and removed from the landfill before having been weighed. However, records were kept by the contractors of the number of and dimensions of the boards salvaged from each trailer. From that data, and utilizing a “typical” density factor for spruce/fir wood, an fair estimate of the weigh was calculated.

The walls studs in several of the trailers were comprised of 2" x 2" or 2" x 3" lumber, and boards of this dimension should only be used in non-bearing applications. Therefore, because of its limited value, 2" x 2" or 2" x 3" lumber was not salvaged for reuse, regardless of the condition. Some 2" x 4" wall studs were salvaged from T-3 and T-5, but in several instances long term leaks had water-damaged the wood. In other instances, separating the studs, intact, from the interior and exterior walls for salvage, then de-nailing each piece, was too laborious when compared to the economic return.

Most of the salvaged lumber came from the floor joists. Because of the way that the trailer is collapsed during deconstruction, many ceiling joists are broken in the process. The majority of the dimensional lumber was taken by Mr. Hutchins partly in exchange for his labor in deconstructing the trailers. The remainder of the salvaged dimensional lumber was donated to the Bristol Senior Citizens Center for the construction of shelving and other miscellaneous projects.

The smaller, unsound, broken, or otherwise unwanted pieces of dimensional lumber or other types of unpainted or untreated wood were disposed in the Bristol Landfill clean wood pile for future burning.

Miscellaneous Items

D & M related that they normally salvage reusable fiberglass insulation during mobile home deconstructing. Typically, this material is used for supplementing existing insulation in other homes, or for sun rooms, workshops, garages, and similar mobile home expansions. However, because of the unsatisfactory condition much of the insulation.

Used mobile home furnaces, electrical breaker boxes, and metal exterior doors that are in serviceable condition are very desirable. Used furnaces can command up to \$125.00, breaker boxes up to \$100.00, and exterior doors up to \$35.00. D & M related that they had “waiting lists” for all of these items. As a probable indication of their worth, four of five furnaces were taken from the trailers before they arrived at the landfill, and the fifth was stolen from T-4 early in the project (along with the front door and some furnishings). Electrical breaker boxes were missing from two of the trailers, and only one of the remaining boxes was salvageable.

Kitchen sinks, cabinets, and countertops, electrical fixtures, bathroom sinks, toilets, and bathtubs, lighting fixtures, interior doors, paneling, and carpeting in good condition all have resale value. Unfortunately, many of these items were damaged or missing from the project homes. Further, D & M has limited storage space at their East Burke, Vermont, shop, so unfortunately the remaining items that normally would be salvaged had to be disposed of.

Material Quantities

The daily weight records that were kept by the contractors were tabularized and are included as Appendices C1 - C5. For each trailer, a total quantity of each individual category of material was calculated. Combined with the contractor’s records of the final disposition of the particular material, the percentage of each trailer which was managed as waste (landfilled and burnable) and recyclables (salvaged as scrap, recycling, or reuse) was calculated.

The total weight of all the loads of each material for a single trailer should equal the gross weight of the complete trailer. Unfortunately, trailers T-1, T-2 and T-3 were not weighed as they were brought into the landfill, but this check on the accuracy of the net weights was performed for trailers T-4 and T-5, both of which were weighed prior to deconstruction. T-4 intact weighed 14,900 pounds, while the sum of its parts weighed 15,026 pounds. T-5 intact weighed 13,200 pounds, while the sum of its parts weighed 13,698 pounds. Both homes weighed slightly more disassembled than intact, but within an acceptable margin of error. Several factors could account for the weight differences. The open, partially deconstructed homes were subject to precipitation which would cause porous materials, such as carpet, drywall, and ceiling tiles, to absorb water and become heavier. Conversely, a few items were stolen or inadvertently not weighed after removal. And finally, the tare weight of the truck used to haul the material to the scale was presumed to be identical in each instance, disregarding varying fuel levels and whether it was before or after lunch.

The weights of the mobile homes, calculated as a sum of their parts, varied from 8373 pounds for T-3, to 15,026 for T-4, or approximately 12 - 17 pounds per square foot. Most unaltered pre-HUD code homes of these 12' x 50' to 14' x 70' standard sizes, would likely fall into this wide weight range. Unsurprisingly, T-4 and T-5 were the heaviest. These two trailers were newer, more recently inhabited, and had been updated with renovations such as drywall interior walls.

Labor

The contractors were required keep to a daily log of their accomplishments, recording the time period, the home worked on, the number of laborers, and what task was performed. The timeframes were divided into 15 minute intervals, but typically a task would require a two-hour time increment. "Tasks" were briefly described and very broad, usually corresponding to the material that was being segregated, e.g., "taking floor off frame," or "took windows out." The effort of hauling materials to the scale, burn pile, or landfill disposal area were incorporated as part of the task. The time demanded for transportation of any materials off site, such as scrap metals brought to a dealer, or resalable objects taken back to D & M's storage, was not included in these calculations.

The log sheets are tabularized in Appendix D1 - D5. For each task during the day, the labor in "person-hours" was calculated by multiplying the number in the crew by the time required to perform the task. All person-hours assigned to a particular task for the deconstruction of a particular project trailer were summed, resulting in a determination of the total hours of labor by task. And finally, the total hours of labor by task were summed, deriving the total hours of labor needed to deconstruct each trailer.

The time needed to deconstruct each the mobile homes ranged from 79 hours for T-5 to 97.39 hours for T-1. Except for T-5, there was good correlation between the size and weight of the trailer and the hours required to dismantle it. Trailers T-2 and T-3 were smaller and lighter and took less time. Trailers T-1 and T-4 were larger, and more substantial and consequently required more time. T-5 was the second heaviest trailer, and was remodeled with drywall over the original paneling, and yet only 79 hours were required to dismantle it.

Specific Weight and Labor Findings

T-1

Trailer T-1 was an average sized home, measuring 12' x 60', with a total weight of the components of 13,061 pounds. This made T-1 the “densest” trailer, at 17.0 pounds per square foot of floor space. T-1 also required the most time to be dismantled: 97.39 person-hours.

“Flooring”, which includes both sub- and finishing flooring, by weight constituted the greatest portion of T-1. The 3,325 pounds of flooring represented 25% of the total weight, or 32% of the non-recyclable, non-reusable fraction. The 1,140 pounds of insulation removed from this home was an unexpectedly large quantity.

The recyclable and reusable elements of T-1 weighed 2,836 pounds, including an estimated 616 pounds of reusable dimensional lumber. This figure represents 22% of the total weight of the trailer.

(Details in Appendices C1 and D1)

T-2

T-2 was the smallest trailer, at 12' x 50'. The trailer weighed the second least, at 9,620 pounds, yet because of its small size, its density of 16.0 pounds per square foot was relatively high. 85.5 person-hours of labor were required to dismantle the trailer.

The “Paneling, Doors....” category, which included all treated and painted wood and wood composites, was proportionally the greatest. The 1,675 pounds of treated wood represented 17% of the entire weight of the trailer, and 27% of the disposable fraction. At the time of removal, the ceiling was waterlogged and remained attached to parts of the roofing members, so this category accounted for a substantial amount of weight.

The recyclable and reusable components of T-2 weighed 3,519 pounds, including an estimated 770 pounds of reusable dimensional lumber that was obtained from dismantling the floor joists. The frame on this home weighed 1,630 pounds, quite heavy for a trailer of this size. The salvaged items represented 37% of the total weight of T-2, the largest proportion of salvageable material of any of the project trailer.

(Details in Appendices C2 and D2)

T-3

T-3 was the only mobile home in the project that originated from the flood clean-up at Palmer's Trailer Court. T-3 measured 12' x 60', and its components weighed 8,373 pounds, making it the lightest of the project trailers, and the least dense at 12.0 pounds per square foot. Dismantling the trailer required 85.25 person-hours of effort.

As with T-1, "Flooring" was proportionally the greatest amount of waste: 38% of the total weight of T-3, and almost half of the weight of the disposable fraction. The flooring, subflooring, and associated structural lumber were included in this category. Unlike most of the other project trailers, the floor joists were not suitable for salvaging.

1,663 pound of recyclable and reusable materials were removed from T-3, including an estimated 261 pounds of 2" x 4" lumber. The portion of the trailer that was salvaged, 20%, was the lowest of the five homes. This low percentage likely was due, in part, to the poor, flood-damaged condition of the home. Very few items could reused.

(Details in Appendices C3 and D3)

T-4

T-4 was a large, 14' x 70', trailer. It had recently been inhabited, and therefore was in good condition upon its arrival. T-4 was that heaviest trailer in the project, weighing 14,900 pounds "over the scale" and 15,026 pounds as a sum of its dismantled components. Its pre-deconstruction density was 15.3 pounds per square foot. Because of its size and the drywalled walls and ceiling, T-4 required 96.39 person-hours to be dismantled.

The "Flooring" category accounted for 3,335 pounds, or 22% of the weight of the trailer. No floor joists were salvaged, so that dimensional lumber was included in the Flooring weight total. At some point, all of T-4's interior walls were remodeled with drywall installed over the original paneling. As a consequence, "Drywall" was the component of the second greatest weight, 2,055 pounds, or 14% of the total weight of T-4.

A considerable amount of light steel scrap was salvaged from T-4: 1,220 pounds. At 1,830 pounds, the salvaged steel frame also was a substantial recycled component. In all, 3801 pounds of recyclable and reusable material was removed from this home, or 25% of the total weight of its components. Several items that would have been salvaged, including the furnace and exterior door, were stolen while the trailer was at the site.

(Details in Appendices C4 and D4)

T-5

T-5 was another large 14' x 70' trailer. Of the five projects trailers, T-5 was in the best condition, and likely had some value as an inhabitable home or camp. T-5 weighed 13,220 pounds as it was brought into the landfill, and 13,689 pounds as a sum of its deconstructed sections. Its pre-deconstruction density was 14.0 pounds per square foot. T-5 inexplicably required only 79 person-hours to deconstruct, even though it was large, heavy, and had drywall walls and ceilings.

“Drywall” constituted the largest amount of waste: 2,630 pounds. “Flooring” was comparatively less than the other trailers, at 1,320 pounds, or 10% of the total weight.

As with T-4, the steel frame and light steel scrap, 1,835 and 1,440 pounds respectively, accounted for the majority of the salvaged material. Also, because of T-5's exceptional condition, D & M were able to salvage 570 pounds of exterior doors, rugs, cabinets, and furnishings prior to its deconstruction. These items were locally donated. In all, 4,884 pounds of recyclable and reusable materials were salvaged from T-5, greatest of any trailer in the project.

(Details in Appendices C5 and D5)

As a whole, the five project trailers weighed 59,769 pounds (29.88 tons) or an average of 11,954 pounds each. Anecdotal evidence suggests that a 6 ton per trailer average is low if compared to a more representative sampling of trailers of this vintage. A factor in the low weights may have been that none of the project trailers had had peaked roofs installed, or had been added onto, as have many similar pre-HUD code homes. Additionally, furniture, fixtures, furnaces and other items were removed from most of the project trailers before they were transported to the landfill.

The portion of each individual trailer that was either recyclable or reusable ranged from 20% to 37%. The aggregated weight of the recyclable and reusable materials was 17,353 pounds (8.67 tons), or 29.0% of the total.

Unpainted and untreated wood that was not salvaged for reuse was transported to the scrap wood and brush pile to be burned as a part of standard landfill operations. In many instances this “clean” wood is a commodity that is used as fuel, chipped for mulch, or used as a bulking agent for compost. At the very least, in Vermont nevertheless, other options exist for the disposal of clean wood outside of a municipal solid waste landfill. Clean, non-reusable wood accounted for 4,865 pounds (2.43 tons), or 8.1% of the total weight.

Finally, the weight of the waste disposed of in the landfill was 37,551 pounds (18.78 tons), or 62.8%.

Economics

As with any waste management alternative, for a long term mobile home recycling program to be successful, economic feasibility is an essential element. Although limited in scope, this project provided baseline data on: the costs of labor, materials, and equipment to dismantle mobile homes; revenues from recyclable and reusable items from the homes; and disposal (and avoided disposal) costs of the residual waste. The data that were generated affords economic information from which private waste management firms, public solid waste management entities, non-profit groups, manufactured housing dealers, and states or municipalities can use in deciding to implement or support a mobile home recycling program.

Although consequential economic data was developed as a conclusion of the Bristol project, no two situations are identical. There are a multitude of factors which will influence the economics of any mobile home recycling enterprise. As examples, every mobile home is constructed (and deconstructed) differently. Commodity markets for the scrap metal fluctuate over time. Distances to recycling markets and disposal facilities are unique to each job site. Landfill tipping fees vary between geographic regions. The economic data that was developed as a result of this project should be thought of as a starting point for further, project-specific, refinement.

Project Costs

The Bristol project was a pilot study researching the feasibility of recycling older mobile homes, and therefore does not precisely reflect the economics of performing such work on an on-going basis. The research related elements - planning, literature review, detailing record keeping, administration, coordination, oversight and report writing - would be minimized or non-existent in an established deconstruction program. Conversely, the pilot project incurred unique, additional unquantified expenses, most notably as the project team’s time and travel costs, donated labor and equipment from the Town, office supplies, telephone usage, and the like. These intangible costs, be they more or less than what would be expected of a permanent trailer deconstruction program, will be excluded from the discussion of project economics. Costs, then, for the Bristol mobile home recycling project were considered as out-of-pocket expenses, minus any actual or assumed revenues gained from the recyclable or salvaged materials.

Out-of-pocket expenses included the cost for retaining the deconstruction contractor, the cost for disposal of the non-recyclable, non-reusable fraction of the dismantled homes in the Bristol Landfill, and the cost of project administration performed by the Town of Bristol.

The original contract price with D & M Recycling to deconstruct the five trailers was \$425.00 per trailer, or \$2100.00 in total. Subsequent to executing the contract, two of the trailers at the landfill burned and replacements were procured. Because they were larger, furnished, and remodeled, additional effort was needed to dismantle the replacement homes. D & M requested an additional \$425.00 for the anticipated extra labor, and the project team agreed. The final contract price was \$2,525.00.

D & M graciously provided the project team with an estimation of their expenses, and consequently, after accounting for revenues, a disclosure of their profits. D & M estimated their out-of-pocket expenses as:

- C Transportation to and from the job site, and at the job site: \$543.04
- C Equipment purchased and rented: \$243.52
- C Day labor: \$768.00

The cost for disposing the waste fraction of the mobile homes in the Bristol Landfill varied. The original FEMA grant to the Town incorporated disposal costs for those trailers originating from Palmer's Trailer Court, but only at a \$50.00 per ton tipping fee. The other costs for the waste disposal not included by the grant as a expenditure of this research project at the Town's standard, and comparatively high, tipping fee of \$150.00 per ton. In all, \$1,823.50 was expended on disposal for 21.53 tons of waste, for a weighted average tipping of \$84.70.

The Town of Bristol was compensated \$265.10 for their role in project administration.

Project Revenues

Under terms of the contract, D&M was entitled to salvage any material from the mobile homes, after the material was sorted, weighed, and documented. Prior to submitting their bid price, D & M representatives performed a walk-through of each home, noting the condition of the reusable components and estimating the amount of scrap metal each contained. D & M remarked that the project homes generally contained less reusable items than ordinarily found in homes to be dismantled. Presumably, the contents of the trailers involved in the flood were damaged beyond use or were missing, and some the contents of the replacement trailers had been removed prior to the homes being transported to the Bristol Landfill. The perceived salvage value of all five trailers was reflected in the contractor's bid price.

Some of the salvage revenue was realized during the execution of the project. The scrap metal (aluminum, brass, copper piping, and galvanized steel) was transported and sold to a local metal dealer as it was accumulated. Several materials, such as the dimensional lumber, steel frames, and some furniture and fixtures were bartered for or sold as they were removed from an individual home. Other items, including copper wiring, and electrical fixtures, were taken back to D & M's shop for processing or storage for future resale.

Invoices were kept by D & M on the scrap metal that was sold, and copies were provided to the project team. Scrap prices paid in December 1999 were:

- C Aluminum -- \$0.20/lb.
- C #2 Copper -- \$0.35/lb.
- C Sheathed Copper wire -- \$0.10/lb.
- C Brass -- \$0.20/lb.
- C Galvanized Steel -- \$0.20/lb.

No light or heavy gauge steel was sold for scrap. The light gauge steel was left in the scrap metal pile at the landfill as the heavy steel frames were bartered for labor and equipment. However, current scrap market prices for these materials are \$0.005/lb. and \$0.01/lb., respectively. The scrap value of the heavy steel is excluded since it was "paid for" non-monetarily, but the worth of the light steel is only deferred until the Town has its metal pile removed.

Reusable dimensional lumber also was bartered for, or donated, but used lumber does have monetary value. A local used building supplies store sells 2" x 4" lumber for \$0.10/ft and 2" x 6" lumber for \$0.30/ft. At those rates, and de-nailed, the 2" x 4" x 8's would retail for \$0.80 each, and the 2" x 6" x 12's would retail for \$3.60 each. However, the latent value of the lumber is not considered in the economic evaluation of the project.

D & M related that there is a viable market for used mobile home parts and supplies, and for building materials that can be reused for site-built housing. Although a few items were collected, unfortunately many normally resalable items were either missing, vandalized, or unworthy of salvage from the five project trailers. Generally, D & M deconstructs mobile homes on-site, often soon after the residents have moved out, and while the home is intact, in good condition, and in a residential location. Most of the homes associated with the Bristol project had not been lived in for a time, or had not been well maintained while inhabited. Further deterioration and vandalism (including arson) occurred after the homes were brought to a fairly isolated area of the Bristol Landfill. The landfill is within Bristol Village, and adjacent to the union high school, making the trailers tempting targets for trespassers.

Typical resale prices for salvaged items in good condition are: furnaces, up to \$125.00; interior doors, up to \$25.00; exterior doors, up to \$35.00; exterior “storm” doors, up to \$45.00; washer/dryers, up to \$50.00 each; dishwashers, up to \$45.00; bathtubs, up to \$25.00; bathroom sinks, up to \$10.00; kitchen sinks, up to \$15.00; fuel oil tanks, up to \$50.00; and windows, \$15.00 - \$25.00.

Unfortunately, in recent years depressed scrap metal prices have greatly altered the economics of mobile home deconstruction. D&M reported that contrary to the \$400-\$800 that they currently charge to dismantle a home, ten years ago there was no cost to the homeowner; the salvage value alone would net the contractors a reasonable profit.

Economic Results

The economics of the trailer recycling project can be distilled to a simple determination of net expenses. In this case, net expenses implies verifiable gross expenses minus verifiable revenues. We have chosen to disregard indeterminate costs and revenues, such as the project team members’ time, or the profit loss from donating materials, or the labor-for-materials bartering that took place. Using actual cost and revenue data limits the uncertainty associated with estimating time and material values, and results in a more realistic economic analysis. Similarly, we have resisted speculating about other deconstruction options that could have been employed, from hiring vocational education students to crushing the trailers simply for the metal content. Certainly there were a number of possible strategies, but attempting to define a range or perform a sensitivity analysis is beyond the scope of the project. Therefore, the economics are:

Gross expenses:

\$2,525.00 - for D&M Recycling to deconstruct the five trailers
\$1,823.50 - tipping fees for disposal of the residual waste in the Bristol Landfill
\$ 265.10 - project administrative costs incurred by the Town of Bristol
\$4,613.60 - TOTAL

Revenues:

\$721.55 - salvaged scrap aluminum, copper, brass, galvanized steel
\$ 15.00 - sold couch
\$736.55 - TOTAL

Net expenses:

\$4,613.60 - gross expenses
\$ 736.55 - revenues
\$3,877.05 - TOTAL, or an average of \$775.41 per trailer

Conclusions

What was an unfortunate natural disaster in Bristol, Vermont, became an opportunity to examine current waste management practices for obsolete mobile homes, and to evaluate whether those practices could be improved upon - economically and environmentally.

Collectively, members of the project team and their respective organizations have a broad scope of experience in solid waste management and manufactured housing in the local, state, and national realms. Nonetheless, managing a project involving the deconstruction of a group of mobile homes was educational to some degree for all team members. Over the course of the project, the team made a number of discoveries concerning mobile home waste management, ranging from simply interesting to consequential to subsequent projects. The major findings from the study are:

- C Manufactured homes comprise a sizable amount of the housing stock in the U.S., and Vermont. It is estimated that there are 19,000 - 23,000 manufactured homes being inhabited in Vermont. Of that number, it is likely that 12,000 - 15,000 are over 25 years old, having been built in an era before national codes and standards were adopted, and are becoming functionally obsolete. Collectively, as these older homes become unwanted or uninhabitable, they represent a immense volume of solid waste. The five Bristol project trailers averaged about six tons each (which is likely a much lower figure than a more representative sampling would indicate). Extrapolating that average across the state suggests that 72,000 - 90,000 tons, or more, of mobile home debris will need to be properly managed in the near future.

- C In the course of the Bristol project a number of contacts were made with individuals and groups that work with mobile homes or their residents on a daily basis: the Manufactured Housing Institute, mobile home dealers, transporters, low income advocacy groups, the State human services agencies, municipal officials, and waste management firms. Almost universally, it was asserted that the issue of managing obsolete trailers is expensive and problematic, is growing in magnitude over time, and does not receive the attention it deserves. The Bristol project only enumerated what these knowledgeable few already understood.

When mobile homes reach the end of their serviceable life, they become an economic liability that the owner is often unwilling or unable to assume. Unlike a junk automobile that has at least a few dollars value, or a derelict building on land that may be valuable, at some point old trailers invariably will cost someone money to dispose of. Depending on the size, condition, and location of the trailer, proper disposal can cost \$1500.00, or more. A lack of maintenance due to financial constraints is frequently the cause of an owner-occupied home becoming uninhabitable, and those same circumstances often result in abandonment of the home. There simply is no money, or there are greater financial priorities than paying for disposal.

In other instances, the obsolete mobile home is taken by a dealer as trade for a newer model or a newly manufactured home. The burden now shifts to the dealer, who must either attempt to resell the home for a nominal amount, or attempt to make the arrangements for transportation and disposal. Neither option is always feasible, as the particular home may be unsalable, and disposal contractors and disposal facilities are scarce, particularly in Vermont. The trade-ins often sit on a dealers or transporters back lot. Not only is the process inconvenient, it costs the dealer money, which is ultimately passed on to the consumer.

- C With the quality of today's manufactured homes rivaling site-built homes, the manufactured housing industry is anxious to shed the image of makers and sellers of the shoddily made and quickly depreciating starter housing. The industry is very interested in programs for the management of older mobile homes; seeking approaches that are economical, stable, efficient, and environmentally responsible.
- C Obsolete mobile homes that are abandoned in place, or are transported and abandoned in a remote location, are an eyesore to neighbors and passersby. While a dilapidated building may have "charm", a deserted trailer rarely invokes more than scorn.
- C Physically, mobile home deconstruction or recycling can be done, and in fact is being done on a limited scale. The project team learned of projects ongoing in Wisconsin, Illinois, and North Carolina, and in Vermont at least two private contractors and one landfill operator are dismantling mobile home for their salvage value.

There is a wide range of methods of mobile home deconstruction, from very equipment intensive to very labor intensive. The method employed depends on the objectives of the deconstruction. The Bristol project relied primarily on manual labor as both the project team and contractors wanted to salvage as many reusable or recyclable materials as feasible. Operators of the Burgess Brothers, Inc., Landfill, in Bennington, Vermont, perform only a minor amount of manual salvage before using grapples and excavators to separate the exterior aluminum and frame from the remainder of trailer. At the other extreme from the Bristol project, in Detroit, a Michigan Manufactured Housing Association-sponsored program utilizes automobile shredder equipment to first shred mobile homes, then separate ferrous and non-ferrous metals from the residuals. Virtually no manual salvaging is performed prior to shredding.

- C Mobile home deconstruction, performed in a manner similar to this project, is physically demanding work. The jobs are performed outdoors, year around, which in Vermont often means working in cold temperatures and snow covered ground, when most of the construction industry is on hiatus.

Experience on the job site is invaluable. With most occupations, there are efficient and inefficient means of performing a given task, and mobile home deconstruction is no different. The homes are dismantled in a controlled sequence that allows for resalable items to be removed intact, and for the maximum practical amount of recyclable materials to be salvaged. At the same time, the deconstruction work must progress quickly, as labor and transportation to and from the job site are major costs that can seriously erode profits. Truly, “time is money”. For a standard trailer, D&M Recycling strives for a three-day start-to-finish schedule.

- C There is a viable, if not lucrative, market for used mobile home components. Furnaces, sinks, toilets, showers, faucets, exterior and interior doors, electrical breaker boxes, oil tanks, washer/dryers, and stoves, and other functional components can be, and are, reused. Insulation and lumber removed from dismantled trailers are often reused in other trailers, additions, or outbuildings. The steel trailer frame components, and axles and wheels can be used to fabricate utility trailers. While demand is high, the resale value of these items is generally small. Still, the materials are kept out of landfills, and typically lower income homeowners and renters are provided a source of affordable furnishings and home improvement supplies.

- C Transportation costs were not incorporated into the Bristol project data but would need to be considered if a continual mobile home deconstruction program was being designed. There are two possible scenarios for a long-term program: (1) the homes are dismantled where they are located, or (2) the homes are transported to a centralized location to be dismantled.

In the first instance, the residual waste from the on-site deconstruction process would typically contained in 30 cubic yard “roll-off” containers. These containers would then be transported by a waste management firm to a solid waste transfer station or disposal facility. The cost to transport solid waste is dependent on the region (including within Vermont), the service provider, and, as there are economies of scale, the amount of waste generated. On average, the cost of having a 30 cubic yard roll-off dropped off empty, then hauled away full, is \$200.00 - \$250.00, plus disposal fees. If a mobile home is efficiently dismantled single 30 cubic yard roll-off with a 10 ton maximum capacity should suffice. Tipping fees at Vermont disposal facilities range from \$60.00 - \$85.00 per ton.

In the other scenario, the intact mobile home would be transported from its original location to a fixed dismantling facility. The cost of mobile home transportation varies with the condition of the home, the effort needed to prepare the home for hauling, and the distance of the haul. Intuitively, the set-up and take-down costs for taking an uninhabitable trailer on its “final ride” will be less than a for a new manufactured home over the same distance. Generally, the cost to transport a trailer destined for deconstruction up to 40 miles would be \$300.00 - \$600.00. Once dismantled, the residual waste would need to be transported as outlined in the paragraph above.

Both methods have other advantages and disadvantages. In many cases (as was discovered in Bristol) the older mobile homes are in very poor condition and not roadworthy, or that the effort of making them transportable would be cost or time prohibitive. In comparison, a centralized deconstruction location - especially under cover - provides a more productive work environment. Equipment would not have to be transportable, there would be no commuting time for the crew, and markets for the recyclable and salvageable materials could be strengthened if the operation was based in one location.

- C Salvaging efforts resulted in 20% to 37% of the gross weight of the individual trailers being diverted from the landfill as either reusable or recyclable materials, with a cumulative average of 29%. The remaining 71% of the trailer debris was buried or burned at the landfill. The project team believes that this range reasonably represents what can be, and should be, salvaged from a “typical” trailer of this vintage. Proportions less than 20% would suggest missed opportunities and the disposal of valuable resources that should have been saved. Salvage proportions approaching or exceeding 50% are possible, but current reuse and recycling markets do not warrant the effort to attain those levels of diversion.

- C 8.67 tons of reusable and recyclable materials and 2.43 tons of non-reusable, clean wood (11.1 total tons) were segregated during the project. Had this material been landfilled, the additional cost, at the project's weighted tipping fee of \$84.70 per ton, would have been \$940.17. Furthermore, landfill "airspace" is a valuable and limited resource. Publicly-owned landfills, in particular, ardently attempt to conserve this resource for the future use by their citizens. Applying a reasonable waste density estimate for the Bristol Landfill of 1000 pounds per cubic yard, 22 cubic yards of landfill airspace was conserved if compared to whole trailer disposal.
- C The project expenses were \$4613.60, and included retaining the contractor, landfill disposal fees, and the Town of Bristol's modest administration fee. Aside from the small payment to Bristol, no administrative costs were included as expenses, and D & M did not increase their fee to account for the extra material handling and recordkeeping that was a part of this project. Aside from transportation of the trailers to the deconstruction site, the project costs were little different than if any five trailers were dismantled and disposed of. Thus, the financial data from the Bristol project can be utilized as a starting-point to estimate the costs of a full-scale mobile home deconstruction program.
- C Actual income from the sale of salvaged materials was \$736.55. Except for one item of furniture, all revenue was derived from the sale of scrap metal. The income level was likely half of what it could have been under different circumstances, for two reasons. First, several of the Bristol project mobile homes had been damaged, and furnishings and fixtures had been removed before and after they were brought to the landfill. Second, D & M was obligated to forsake a number of salvageable items for want of storage space. As examples, a number of kitchen and bath fixtures, and doors were in resalable condition, but unfortunately had to be landfilled.

To a large degree, the revenue gained from a mobile home deconstruction is dependent on scrap metal market prices. Comparatively, labor and waste disposal costs are too great for deconstruction to be a profit making venture, but the scrap value does help to offset these costs. In the Bristol project, expenses were reduced 19% by the sale of scrap metal alone. Unfortunately, commodity prices at the time of the Bristol project were at one of the lowest levels as they have been in recent history. For example, the Northeast Resource Recovery Association (NRRA), a nonprofit coalition which oversees a recyclables market cooperative for new Hampshire and Vermont municipalities, reported that light scrap steel prices declined from \$42.00 per ton in July 1997 to \$20.00 per ton in December 1999. [8] *Waste News*, a solid waste industry journal, reported a similar nationwide trend in the price of "white goods" - appliances and comparable light scrap steel - as average prices fell from \$35.00 - \$45.00 per ton in 1996 and 1997, to a low of \$10.00 - \$15.00 per ton in early 1999, before rebounding to \$20.00 - \$25.00 per ton at about the time of the Bristol project. [9] Both NRRA and *Waste News* data indicate a continued rise in scrap steel prices in 2000.

Aluminum prices have fluctuated moderately in the past three or four years, and were not at either extreme in December 1999. Copper prices rose from \$0.80 - \$0.90 per pound in the fall of 1996 to over \$1.20 per pound in mid-1997, before declining back to about \$0.80 per pound at the time of the Bristol project.

- C The time required to dismantle each trailer ranged from 79 to 97 person-hours, with an average of 88.7 person hours, and a total effort of 443.53 person-hours. Trailers T-2, T-3, and T-4, had a predictable correlation between their size and the time necessary for their dismantling. That is, the two smaller homes, T-2 and T-3, required less time to dismantle, while the larger, T-4, required more time. Trailers T-1 and T-5 did not conform to the expected size/time relationship. Although dimensionally small, T-1 was quite heavy and well built, attributes that likely caused a longer deconstruction process. Trailer T-4 was large and heavy, and took the least amount of time to dismantle, possibly because the crew was slightly more efficient (or cold and anxious to be done!) by the final home.

The D & M Salvage crew worked 25 days on the project, more than their customary goal of three working days per trailer, or 15 total days. Progress was slower than usual for several reasons:

1. The project was predicated on a level of materials separation and handling that was atypical to the contractor's standard work practices. In any other circumstance, the residual waste would be mixed together and placed into a single container for disposal, rather than being sorted into like categories for data collection purposes.
2. Similarly, once segregated, each small load of similar material had to be weighed, recorded, then managed as waste or salvage. The shuttling from the trailer location to the truck scale to the working face of the landfill, and the required record keeping, invariably decreased D &M's productivity.
3. The time of year did not allow for long, productive work days. The crew commuted 90 miles, each way, every day. Work typically commenced at 9:30 a.m., and darkness forced a work stoppage no later than 4 p.m. And, although the weather over the time period was relatively mild for November and December in Vermont, there were days of cold, snow, and icy rain that hurt productivity.

In reviewing the time spent by the contractors deconstructing the project trailers as compared to their gross income, it is apparent that the profit margin was slight. D & M grossed \$3261.55, and spent 443.53 hours in doing so, equating to an average gross wage of \$7.35 per person per hour. Equipment, transportation, depreciation, insurance, taxes, and all other expenses would need to be subtracted from these figures to determine net wages or profit. D & M acknowledged that their bid was low to bolster their chances of being awarded the contract in hope of gaining name recognition and additional future work.

- C As expected, deconstructing the trailers did not result in economic savings. Had the five trailers simply been transported to the Bristol Landfill the disposal cost would have been \$2531.28, as compared to the net project cost of \$3877.05.
- C Conclusions are summarized in the table below:

BRISTOL MOBILE HOME PROJECT SUMMARY

Gross Weight of Five Trailers:	29.88 tons
Salvaged Fraction:	8.67 tons or 29%
Clean, Non-Reusable Wood:	2.43 tons or 8%
Landfilled Fraction:	18.78 tons of 63%
Total Deconstruction Time:	444 person hours
Per Trailer Range:	79 - 97 hours
Gross Project Cost:	\$4613.60
Salvaged Material Value:	\$ 736.55
Net Project Cost:	\$3877.05
Average Cost Per Trailer:	\$ 775.41

Recommendations

Waste management of mobile homes is a significant, but overlooked problem. The expense of proper disposal is a financial burden that is continually deferred as a mobile home, or the land it is on, changes hands. Ultimately, the obligation falls onto those who can least afford it, the low income homeowner, or is placed reluctantly on the mobile home park owner, or manufactured housing dealer. Even with willingness and financial ability, disposing of a mobile home may not be an easy task. In Vermont, one landfill accepts intact mobile homes and a few contractors specialize in mobile home deconstruction. Aside from those, the remaining legal option is to retain a contractor to demolish the home, fill roll-off containers with the remains, and transport it to a landfill as construction and demolition waste - costly and a waste of resources.

The project team sees this study as the first step in assisting the development of improved mobile home waste management practices. The team's recommendations are based on the consequences of this unique project, and the background research that was associated with it. As the team is most familiar with the political, economic, and waste management circumstances in Vermont, the specific recommendations have a Vermont focus, and thus may or may not be applicable elsewhere. Moreover, a problem such as mismanaging obsolete mobile homes can be easily solved - if money was no object. The team realizes that funds are always limiting, and therefore our recommended initiatives are made with economics as a major consideration. The project team advocates:

- C The deconstruction of older mobile should be encouraged whenever feasible. Obsolete mobile homes are an eyesore and represent a extensive volume of waste if mismanaged. Deconstruction does not save on initial costs, but does conserve resources, preserves landfill volume, creates employment opportunities, and supports the used building supply and scrap metal industries.

Mobile home deconstruction need not be as elaborate as the Bristol Project to be worthwhile. Reusable fixtures and furnishings, the exterior aluminum sheathing, copper and brass piping, and wiring represent easily obtainable, relatively valuable components. At a minimum, these items should be salvaged from any home before disposal.

- C In the short term, municipalities or solid waste management authorities should consider sponsoring mobile home "round-ups", which have proven successful for junk cars. It is unlikely that such a publically sponsored program could fully subsidize the deconstruction cost of a large quantity of trailers. However, partial funding, if coupled with economies of scale and convenience, may be enough of an incentive to attract a sizable number of homes.

- C Two specific logistical options seem to exist for a permanent mobile home deconstruction program: either the deconstruction crew travels to the location of the project trailer, or the project trailer goes to a central location. There are benefits and drawbacks to both. However, as is taking precedence in other parts of the country, and advocated by our own contractor, it appears that a fixed, centralized location is offers greater advantages.

- C Vermont state government, solid waste management districts, and the manufactured housing industry should support one or more mobile home deconstruction entities proposing to establish such a facility. The facility could be a profit or non-profit entity, public or privately owned and operated, or any combination of these.

- C Mobile home deconstruction holds great promise as a training resource or entry level employment opportunity. While it is important that the entity performing the deconstruction work is accomplished, and that an experienced person or persons be on the job site at all times, the bulk of the labor can be done by relatively unskilled or inexperienced workers. In that sense, trailer deconstruction may lend itself to unique employment opportunities such as employing low-risk criminal offenders (as was done in a State of Wisconsin mobile home reconditioning project [10]), vocational-technical school students, welfare-to-work participants, underskilled workers, first time or youthful offenders, vocational rehabilitation program enrollees, community service program enrollees, and “Step-Up Program” trainees (women learning construction industry skills) would all be candidates for employment on a mobile home deconstruction crew. Individuals would earn a living and learn workplace and vocational skills, while the community benefits from a larger and more skilled workforce.

References

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4. Personal communication with Jim Blackwell, Scotland (NC) County Engineer, January 2000.
5. "Recycling Image," Modern Homes, November - December 1999, and personal communication with Tim DeWitt, Executive Director, Michigan Manufactured Housing Association, February 2000.
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7. Personal communication with Penny Maguire, Burgess Brothers, Inc., Bennington Vermont, April 2000.
8. "Customer Activity Report," Northeast Resource Recovery Association, Concord, NH, April, 2000.
9. "Commodity Pricing", Waste News Website (www.wastenews.com), April 2000.
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Appendix B

BRISTOL MOBILE HOME DECONSTRUCTION PROJECT
DAILY LOG

DATE _____

TIME (FROM -TO)	TRAILER #	CREW	TASK

COMMENTS:

FORM COMPLETED BY: _____

TRAILER 1 (T-1)

WEIGHT OF COMPONENTS

SOLID WASTE:

DATE	PANELING, DOORS... ¹	INSULATION ²	CLEAN WOOD ³	ROOFING	FLOORING ⁴	RUGS	DRYWALL	ELECTRICAL FIXTURES	MISC. ⁵
11/24/1999	1460	320							
11/27/1999	700	820	820				1700		680
11/28/1999			400		500				
11/29/1999					740				
11/30/1999					840				
12/3/1999					1245				
TOTALS	2160	1140	1220	0	3325	0	1700		680

WASTE TOTAL: **10225** pounds

¹ : Includes all treated, non-burnable wood ² : All ceiling and wall fiberglass insulation ⁵ : ceiling, glass, etc.
³ : Untreated wood to be burned ⁴ : Includes finish- and subflooring

RECYCLABLE AND SALVAGABLE MATERIALS:

ALUMINUM	586
COPPER	24
BRASS	8
WIRING	52
GALV. STEEL	50
"TIN"	700
STEEL FRAME	800
LUMBER	616 (32 - 2"X6"X12')

TOTAL SALVAGE 2836 pounds

TOTAL WEIGHT OF SALVAGE	2836 OR	22%
TOTAL WEIGHT OF WASTE	10225 OR	78%

TOTAL WEIGHT OF TRAILER : **13061** POUNDS

TRAILER 2 (T-2) WEIGHT OF COMPONENTS

SOLID WASTE:

DATE	PANELING, DOORS... ¹	INSULATION ²	CLEAN WOOD ³	ROOFING	FLOORING ⁴	RUGS	GLASS	ELECTRICAL FIXTURES	CEILING
11/13/1999	920	160	530				110		
11/14/1999				725				75	
11/16/1999			500						
11/20/1999					800				
11/21/1999	755	200							1401
TOTALS	1675	360	1030	725	800	0	110		1401
WASTE TOTAL:			6101 pounds						

¹ : Includes all treated, non-burnable wood

² : All ceiling and wall fiberglass insulation

⁵ : ceiling (wet), includes associated structural lumber

³ : Untreated wood to be burned

⁴ : Includes finish- and subflooring

RECYCLABLE AND SALVAGABLE MATERIALS:

ALUMINUM	351
COPPER	32
BRASS	4
WIRING	52
"TIN"	380
APPLIANCES	300
STEEL FRAME	1630
LUMBER	770 (40 - 2"X6"X12')
TOTAL SALVAGE	3519

TOTAL WEIGHT OF SALVAGE	3519	OR	37%
TOTAL WEIGHT OF WASTE	6101	OR	63%

TOTAL WEIGHT OF TRAILER : **9620** POUNDS

TRAILER 3 (T-3)

WEIGHT OF COMPONENTS

SOLID WASTE:

DATE	PANELING, DOORS... ¹	INSULATION ²	CLEAN WOOD ³	ROOFING	FLOORING ⁴	RUGS	GLASS	MISC.
11/10/1999	860	75					80	
11/16/1999	500	400	400		600			
11/18/1999					500	600		
11/20/1999		140		400				
11/21/1999					450			785
11/28/1999					1705			
TOTALS	1360	615	400	400	3255	600	80	785

WASTE TOTAL: 6710 pounds

¹ : Includes all treated, non-burnable wood ² : All ceiling and wall fiberglass insulation

³ : Untreated wood to be burned ⁴ : Includes finish- and subflooring

RECYCLABLE AND SALVAGABLE MATERIALS:

ALUMINUM	345	
COPPER	2	
BRASS	5	
WIRING	48	
"TIN"	440	
STEEL PIPING	82	
STEEL FRAME	480	
LUMBER	261	(32 - 2"X4" X 8')

TOTAL SALVAGE 1663

TOTAL WEIGHT OF SALVAGE	1663	OR	20%
TOTAL WEIGHT OF WASTE	6710	OR	80%

TOTAL WEIGHT OF TRAILER : 8373 POUNDS

TRAILER 4 (T-4) WEIGHT OF COMPONENTS

SOLID WASTE:

DATE	PANELING, DOORS... ¹	INSULATION ²	CLEAN WOOD ³	ROOFING	FLOORING ⁴	DRYWALL
12/4/1999	1690		480			1280
12/5/1999		365	410	1705		
12/7/1999		535			370	775
12/8/1999					770	
12/9/1999					1065	
12/10/1999					1130	
TOTALS	1690	900	890	1705	3335	2055

WASTE TOTAL: 10575 pounds

¹ : Includes all treated, non-burnable wood

² : Included in "roofing"

³ : Untreated wood to be burned

⁴ : Includes finish- and subflooring

RECYCLABLE AND SALVAGABLE MATERIALS:

ALUMINUM	626	
COPPER	10	
BRASS	6	
WIRING	66	
"TIN"	1220	
GALV. STEEL	40	
STEEL FRAME	1833	
LUMBER	650	(est. 34 - 2" x 6" x12")

TOTAL SALVAGE 4451 pounds

TOTAL WEIGHT OF SALVAGE	4451 OR	30%
TOTAL WEIGHT OF WASTE	10575 OR	70%

TOTAL WEIGHT OF TRAILER : 15026 POUNDS

TRAILER 5 (T-5)

WEIGHT OF COMPONENTS

SOLID WASTE:

DATE	PANELING, DOORS... ¹	INSULATION ²	CLEAN WOOD ³	FLOORING ⁴	DRYWALL	MISC. ⁵
12/10/1999	950	130			2630	
12/14/1999		360	500	500		860
	695	535	825	820		
TOTALS	1645	1025	1325	1320	2630	860

WASTE TOTAL: 8805 pounds

¹ : Includes all treated, non-burnable wood

² : All ceiling and wall fiberglass insulation

³ : Untreated wood to be burned

⁴ : Includes finish- and subflooring

RECYCLABLE AND SALVAGABLE MATERIALS:

DOORS, RUGS, CABINETS, ETC.	570	
ALUMINUM	710	
COPPER	12	
BRASS	0	
WIRING	56	
"TIN"	1440	
STEEL FRAME	1835	
LUMBER	261	(32 - 2" X 4" X 8')
TOTAL SALVAGE	4884 pounds	

TOTAL WEIGHT OF SALVAGE	4884	OR	36%
TOTAL WEIGHT OF WASTE	8805	OR	64%

TOTAL WEIGHT OF TRAILER : 13689 POUNDS

TRAILER 2 (T-2) LABOR IN PERSON HOURS

DATE	11/10/1999	11/11/1999	11/13/1999	11/14/1999	11/15/1999	11/20/1999	11/21/1999	
TASK								TOTAL BY TASK
REMOVE PANELING		9	6					15
REMOVE FURNISHINGS	12							12
REMOVE EX. SIDING		4.5						4.5
REMOVE DRYWALL								
REMOVE INSULATION			6					6
REMOVE FIXTURES		4.5	2					6.5
REMOVE CEILING				4				4
REMOVE ROOF				4				4
COLLAPSE TRAILER								
REMOVE RUGS								
REMOVE LUMBER								
REMOVE FLOORING						14	14	28
REMOVE WINDOWS								
MISC. CLEAN UP					5.5			5.5
SITE RESTORATION								
TOTAL BY DATE	12	18	14	8	5.5	14	14	
								GRAND TOTAL
								85.5 hours

TRAILER 3 (T-3) LABOR IN PERSON HOURS

DATE	11/10/1999	11/13/1999	11/18/1999	11/20/1999	11/21/1999	11/28/1999	
TASK							TOTAL BY TASK
REMOVE PANELING	12.5	7					19.5
REMOVE FURNISHINGS	4.5						4.5
REMOVE EX. SIDING	5.25	4					9.25
REMOVE DRYWALL					7		7
REMOVE INSULATION	0.5						0.5
REMOVE FIXTURES	1.5						1.5
REMOVE CEILING							
REMOVE ROOF			3	14	7		24
COLLAPSE TRAILER							
REMOVE RUGS			3				3
REMOVE LUMBER							
REMOVE FLOORING						16	16
REMOVE WINDOWS							
MISC. CLEAN UP							
SITE RESTORATION							
TOTAL BY DATE	24.25	11	6	14	14	16	
							GRAND TOTAL
							85.25 hours

TRAILER 5 (T-5) LABOR IN PERSON HOURS

TASK	DATE	12/7/1999	12/9/1999	12/10/1999	12/12/1999	12/13/1999	12/14/1999	TOTAL BY TASK
REMOVE PANELING								
REMOVE FURNISHINGS								
REMOVE EX. SIDING		5						5
REMOVE DRYWALL			4	9				13
REMOVE INSULATION								
REMOVE FIXTURES								
REMOVE CEILING								
REMOVE ROOF						11		11
COLLAPSE TRAILER								
REMOVE RUGS								
REMOVE LUMBER								
REMOVE FLOORING					30			30
REMOVE WINDOWS								
MISC. CLEAN UP					8		12	20
SITE RESTORATION								
TOTAL BY DATE		5	4	9	38	11	12	
		GRAND TOTAL		79 hours				