
Construction Materials Management Guidelines

For economy and ecology
in design and construction

Review

Reduce

Reuse

Recycle

A product of AIA Houston for the Governor's Energy Office

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Clean Houston

Disclaimer:

This guidebook with its tables, charts, reference data, market directory and other contents, is provided as a service to the construction industry to promote recycling as an alternative to waste landfilling. The quantities and costs presented herein are not to be construed as accurate for anything but estimating purposes. Data presented in the guidelines is average for the conditions that exist in the Houston area in 1993 as experienced by the Program Team. Users of the guidelines must obtain quotations from haulers, recyclers and others on which to base any business decisions. Companies in the directory have given information on a voluntary basis -- their name in this book does not constitute an endorsement by the authors, sponsors or endorsers. The directory is not intended to be a complete listing of waste management and recycling resources, and omissions are not intentional. It is up to the user of the market data, as well as any other information in this book to establish its validity for the user's purpose.

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Introduction

These Guidelines

The intent of this book is one thing: To serve as a tool for the construction industry to design into projects better materials use for greater profitability, resource conservation and pollution prevention.

The guidelines are for anyone involved in the creation of a building -- residential, commercial or institutional; public or private.

Architects, Estimators and Purchasers: You will be interested in the Sections I & II on planning waste reduction, reuse and recycling, including the sample waste management specifications and the impact of waste management on project cost.

Contractors and Sub-contractors: In addition to the planning Sections I and II, Section III is for you. In addition to the logistical aspects of waste reduction and management, you will be interested in monitoring how well your waste reduction and recycling programs are going.

These guidelines provide worksheets for you to analyze specific savings opportunities for your projects and presents a directory of recyclers in the greater Houston region that will accept a variety of construction waste materials. It presents concepts about the impact of materials waste on construction cost; facts about the amount of construction waste that can be recycled, suggestions on how to improve construction operations and practices.

Your Opportunity

A great opportunity for the construction industry to reduce cost and increase profit and competitiveness is in the area of materials management. Better materials use can, additionally, result in improved project economy, conservation of natural resources and reduced pollution. Therefore, the opportunity to reduce cost and increase profits is also the opportunity to protect the environment.

A few hours spent in planning can produce project cost savings through:

- ❖ Reducing the amount of materials purchased
- ❖ Better use of the materials purchased
- ❖ Reduced labor in handling materials and having to purchase make-up materials
- ❖ Reduced waste and disposal costs

The AIA Construction Materials Recycling Demonstration Program

A year-long research and demonstration program was conducted in the Houston area. The waste from two commercial buildings and four houses was managed for recycling. Refer to Appendix III for more detailed information on the recycling demonstration program

In this demonstration program both on and off-site waste separation methods were employed. The insights, suggestions and figures in these guidelines are based on this experience of actually recycling construction waste.

Approximately 35% of the waste from a new commercial building was recycled. If this could have been done on all commercial construction projects in the Houston area over the past twelve months, about 11,600,000 lbs of commercial construction waste could have been recycled (based on City of Houston commercial building permit statistics). About 38% of the waste from the houses were recycled. If the waste from all new residential construction (single- and multi-family) was recycled to this degree, an estimated 31,000,000 lbs of waste would have been recycled (mostly wood).

Simple waste recovery and recycling programs at Houston's construction sites could have a significant impact on the region's landfill burden. And waste reduction at the jobsites could have an impact on construction costs.

Your Input & Feedback

If you have data, information or case histories to report, please contact AIA Houston. We would be pleased to receive more information and success stories.

Acknowledgments

Demonstration Participants

Commercial Projects

On-site separation

Brown & Root, Inc. -- Brown & Root Recruiting Center, Clinton & Hirsch streets, Houston, Texas

Brown & Root Building Company, Construction Manager, and about 15 contractors.

R.C. Construction Services hauled separated materials to Vista Fibers (Plastics), Organic Resources and WRS (wood) and Acco Waste Paper (cardboard). Some wood was recovered for use by A New Life homeless facility. Proler Metal Processing provided a container and hauled steel.

Off-Site Separation

BMC Properties -- BMC Software Building, near Briarhurst and West Belt, Houston, Texas

W.S.Bellows Construction Company, Inc., General Contractor, and a dozen subcontractors who built out the 19th floor which was the particular subject of the study.

Custom Waste was the hauler, WRS the off-site separation facility.

Residential Projects

On-site separation

Village Builders -- Two houses in Parkway Villages, Houston, Texas

Goodwill Construction Services collected and separated the materials on-site. R.C. Construction Services hauled cardboard to Vista Fibers, waste brick to Able Brick, and plastic and metal to WRS. BPI Hauled waste material that was insufficiently sorted to WRS for additional separation.

Off-Site Separation

Village Builders, Brookwood subdivision, Clear Lake, Texas

Roadrunner Construction Services cleaned the sites and loaded the waste into containers. WRS provided containers, hauled, recycled at their materials recovery facility, and provided detailed waste content information.

Landfill-Only Information

Royce Homes provided information.

Guidelines Workshop Participants

A workshop was conducted to gain information and guidance from the construction industry about the design and content of these guidelines. Participants included:

Dan Dennehy, H.A. Lott

Rusty Coleman, Harvey Builders

Duane Bradshaw, Duane L. Bradshaw, AIA

Frank Knight, Fisk Electric

Stan Marek, Marek Brothers

Paul Marek, Marek Brothers

Percy Townsend, Marek Brothers

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5
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Section I: Managing Construction Materials & Waste

Construction Economy & Ecology

Cost of Waste

The cost of waste is more than simply the cost of getting it to a landfill and dumping it. The cost of waste really is:

- Original cost of material
- + Delivery cost
- + Handling cost
- + Management cost
- + Cleanup cost
- + Waste hauling cost
- + Tipping fee
- = Total cost of construction waste

Many usable or reusable pieces of material can be seen in a construction trash containers. Examples include lighting ballasts, electrical switches and other hardware and fasteners; pails of roof penetration sealant with material in them; and various lengths of piping and conduit.

This is the typical materials and waste management method: once a piece of material or hardware is left on the floor or on the ground it is picked up and deposited in the trash container.

But what if some other way of handling materials could be designed and implemented so that more of the materials purchased for a project were actually used to construct the project and less of it ended up in the trash -- and that what did end up in the trash container truly was useless? A 2' piece of lumber, or a short piece of conduit or pipe could be just what a worker needs for a particular application.

Greater Savings

The recycling demonstration program established that recycling construction waste is technically feasible in the Houston area. Through the course of the demonstration, it became apparent that recycling is just the final step that can be taken in construction waste management to reduce landfill burden and support resource conservation.

Greater savings in both economic and environmental cost may be possible through more prudent use of the materials in the first place and through caring for the materials until they are no longer useful.

This would require changes in how the construction industry does business. Everyone involved in the construction process from the architect to the trade worker is a participant in this change.

Cost of Non-Management

Look in the jobsite trash containers. The total cost of this construction waste on your project is due to the construction industry's current operating practice and

level of attention to care of materials. What if more attention were paid to materials management on the site? What if more of the materials that showed up on the site were actually used to construct the building? Could less material be purchased?

Would recovered materials, fasteners and hardware pay for the

cost for the materials and waste planning and clean up labor to recover the items? Would the savings exceed the cost to provide overall project savings? Somewhere is the optimum between the cost of materials management and the cost of waste, as conceptually presented by Figure 1.

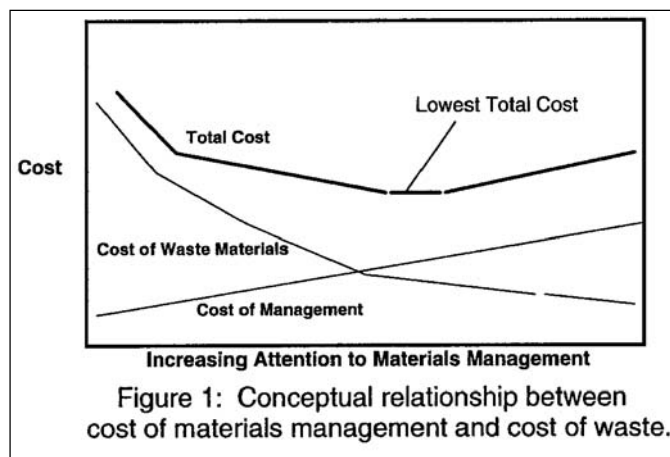


Figure 1: Conceptual relationship between cost of materials management and cost of waste.

Materials and Waste Management

Be Proactive

Materials use -- and materials reuse, reduction and recycling -- begins in the planning stages of a project. It starts with the architect, proceeds through the engineer, the estimator, the purchaser, the construction manager and finally the contractors.

Materials cost control and, therefore, profitability starts with a plan. Once the material is on site and especially once its been cut, it is too late to plan but for its fate. But with carefully scrutinized operational procedures and construction practices, a plan can be developed and implemented to save significant costs in materials.

Many People are Involved

Successful materials and waste management -- like any successful project -- relies on the skills of many professionals from the architect and designers through project management to the trade contractors.

Table I presents a list of those people typically involved before the materials arrive on site, and the roles they play in effective materials management.

Team Member	Role in Materials Management
Architect	Designs for best use of standard sizes, for multiple applications and for their recyclability. Specifies materials with recycled content, responsible packaging and from renewable resources.
Engineer	Ensures appropriate structural component dimensions, quality and spacing for use of standard fasteners and materials for multiple applications and recyclability. Specifies materials with recycled content, responsible packaging and from renewable resources.
Estimator	Uses latest materials takeoff technologies and exercises accuracy in estimates. Reviews actual waste generation data and updates actual waste factors regularly.
Purchaser	Plans purchases and deliveries to reduce surplus and to balance materials maintenance during on-site storage versus transportation energy consumption. Specifies recyclable and returnable packaging.

Table II lists those people directly involved in the use of the materials. They may participate in the planning process, since they know first-hand the actual site and working conditions.

For commercial buildings or multiple-housing projects, it may be prudent to employ a Site Materials Manager, a function that is not common in today's construction practice. Or the role may be given to one or more individuals as a part of their assignment on smaller projects.

Team Member	Role in Materials Management
Site construction management	Applies the materials management plan to the site and oversees its implementation. Takes into consideration physical space available and ensures subcontractors are familiar with and committed to the plan.
Site materials manager	Keeps track of new materials, cuts and used materials; organizes and stores them for availability by the various trades throughout the project in accordance with the materials management plan.
Subcontract management	Communicates with site management and Materials Manager regarding the types of materials they may be able to use for various purposes, even if temporarily. Ensures trades follow the Plan's practices.
Trade workers	Use materials properly, store new materials properly, handle and cut them carefully for maximum use and minimum waste. Consider using cuts before new pieces.

People not employed by the owner, contractor or subcontractor are a part of the materials management team as well. Suppliers, haulers and recyclers each play a role in the successful reduction of waste and optimum utilization of materials. See Table III.

Team Member	Role In Materials Management
Suppliers	Use recyclable packaging and returnable containers and pallets, and accept the returned containers and pallets or informs the site of others who will accept them.
Recyclers & Haulers	Provide containers for convenient materials storage and retrieval if appropriate. Instruct the site personnel in separation and quality requirements.

Section II: Planning Materials and Waste Management

Materials Management Plan

Materials Management

Materials management is a process: It is how a building is designed and how materials are estimated. It is how materials are acquired and even how the packaging is specified. It is how the delivery schedule is designed. It is how contractors plan materials use and how they manage previously used materials and cuts. It is how waste is managed for use elsewhere or recycling rather than being discarded in a landfill.

It is a culture: It is how the customer expects the contractor, and contractor its subcontractors, and the subcontractors its workers -- to care for and properly manage the materials provided.

The Plan

A Materials Management Plan, formulated through the process of these guidelines, consist of procedures guiding all the professionals and trades involved in the entire process of the building creation from design through finish. It is a two-phase plan corresponding to the Design Phase and the Construction Phase of your project. Within each of these phases are four sections -Review, Reduce, Reuse and Recycle.

The process and results of the planning done in the Design Phase corresponds directly to the site materials management plan.

Design Phase		Construction Phase
Review	⇒	Review
Reduce	⇒	Reduce
Reuse	⇒	Reuse
Recycle	⇒	Recycle

The Plan that you design should consider the "four R's":

Review: Reconsider your design philosophies and practices. Review your company's policies regarding estimating and purchasing and your site construction

practices. And review the sources of those policies and are they valid in today's economy or procedures: ecology?

Reduce: Reduce quantities purchased as well as waste. A way of looking at the estimator's and purchaser's "fudge factor" is that they are actually specifying the waste amounts. More care taken on the jobsite and different cleanup practices could dramatically reduce waste. You could probably create a substantial list of waste-reducing practices.

Reuse: Form lumber is used more than once, but generally for another concrete form. Have you ever thought of using it for blocking? Used plastic film can be stored and used to cover exposed work in case of inclement weather.

Recycle: Plan the recycling of your construction waste before the project starts at the site. Once the project is underway, treat the waste recycling as rigorously as you would the quality of your construction.

Possible Practices to Improve Project Economy and Ecology

How much does it really cost to separate out from the nightly cleanups materials over two feet long as a resource of shorter, cut lengths? How much would it really cost for the trade worker to be a little more careful with the materials he or she uses so less is wasted? And what would it cost for more accuracy in determining the quantities for purchase so less could be bought in the first place?

Would less material be in the trash container if more of it were set aside for use in small piece applications or if the contents of "empty" containers of paints or adhesives were combined?

Draft a list of practices. Some could be listed to be followed as guidelines, the others as rigorous practices.

The following lists are possible things to consider in developing new practices in the construction business. As you review these, listen for old negative arguments against them, then stop and ask yourself if those old arguments are really valid, and if there is any validity to a new way of thinking.

Building Owners and Architects

The following are recommendations to building owners and architects, both of whom establish the fundamentals on which a building is designed and constructed. Where permitted by building code:

- ❖ Consider the selection and specification of products and materials made from recycled materials.
- ❖ Allow contractors to use materials left over from previous construction projects.
- ❖ Design for the use of standard sizes, or specify purchases of mill-cut-to-size to eliminate on-site cut scraps.
- ❖ Specify finished products requiring little or no on site cutting.
- ❖ Specify that waste minimization and recycling are part of the contractor selection criteria
- ❖ Provide materials management, waste reduction and waste recycling specifications to which contractors bid and follow on the construction project.
- ❖ Use excavation dirt and paving debris on site in topographical features.

Builders and Contractors

- ❖ Review construction and other operations practices -- and review the assumptions on which the practices were developed -- to reduce waste and establish reuse and recycling as practices.
- ❖ Buy materials and products with recycled material content
- ❖ Buy materials and products sold in bulk quantities to reduce packaging and encourage the return of unused items to stock.
- ❖ Buy items with little and/or returnable (reusable) containers.
- ❖ Buy items shipped on returnable or reusable pallets.
- ❖ Buy products that require little or no cutting on site.
- ❖ Buy sturdy, long-lasting tools to prevent frequent disposal of worn tools
- ❖ Plan carefully -- buy only the materials you need for a project.

- ❖ Alter the way waste is collected and handled on the job site-- direct waste collectors to recover unused fasteners, connections, bricks, and other items as well as lengths of various materials over a two feet long to be restocked for potential use, then use the short lengths first before cutting long pieces.
- ❖ Take unused products and materials to the next job.
- ❖ Establish waste pickup by recyclers, and landfill only what can't be recycled.

Materials manufacturers and suppliers

- ❖ Manufacture more sizes so contractors can purchase materials closer to the sizes needed (to reduce cuts)
- ❖ Manufacture pre-cut/presized materials to eliminate on-site cuts
- ❖ Reduce packaging
- ❖ Use returnable, refillable packaging
- ❖ Use post-consumer recycled materials in products
- ❖ Accept unused materials for return
- ❖ Use returnable reusable pallets.

Sample Contract Specifications

The specifications on the following pages can be used as a guide to create materials management and recycling specifications for your projects.

These specifications are designed to provide the owner with the opportunity to evaluate the cost or benefits associated with the recycling of construction waste materials prior to the execution of a construction contract.

They also require the specifier be specific about the materials to be recycled.

Contract Specifications

Materials Management, Waste Reduction and Recycling

SECTION 01505 CONSTRUCTION WASTE MANAGEMENT

PART 1 - GENERAL

1.01 SUMMARY

This section includes requirements for managing the [construction] [and] [demolition] waste generated by this project. The cost or savings associated with the work described in this section shall be entered in the appropriate space in the Bid Form under Alternate No. [].

1.02 RELATED REQUIREMENTS

- A. Bid Form
- B. Waste Management Form
- C. Project Waste Management Record Form
- D. Section 01010 - Summary of Work
- E. Section 01030 – Alternates
- F. Section 01500 - Temporary Facilities
- G. Section 01700 - Project Closeout
- H. Section 02050 - Building Demolition
- I. Section 02070 - Selective Demolition

1.03 DEFINITIONS

- A. **WASTE:** All materials removed from the jobsite to be landfilled, burned, recycled, or salvaged for reuse. Pallets, containers, packaging and packing materials in which construction products are delivered to the job site are considered waste materials. New, leftover materials that are returned to the material suppliers are not considered wastes.

1.04 WASTE MANAGEMENT GOALS

- A. The Owner desires that as many materials as possible from this project (whether new construction, remodeling or demolition) be salvaged, reused or recycled in order to minimize the impact of construction and demolition waste in landfills and to minimize the expenditure of energy, cost and depletion of natural resources in the fabrication of new materials.
- B. To this end the Contractor and Subcontractors are encouraged to minimize the generation of waste and salvage materials for reuse before they enter the waste stream. Reuse is a better waste management method than recycling because little or no reprocessing is necessary. Recoverable materials that are not salvaged shall be recycled as in paragraph 1.06.

WASTE MANAGEMENT PLAN

- A. The Waste Management Form included with the bidding documents shall be completed and submitted with each bid. The form shall include the following information and shall be referred to by the Architect/Engineer and the Owner in the evaluation of Alternate No. []:
 - 1. Total estimated quantities of waste materials generated by this project.
 - 2. Estimated quantities of each type of material required to be recycled.

3. Proposed recycling method(s) (i.e.: on-site separation or off-site separation) for each type of material.
4. Proposed on-site methods of storing of waste.
5. Proposed transportation method(s) (i.e.: containers or trucks).
6. Proposed destinations for the recycled material.
7. The name of the person responsible for managing the Plan.

1.06 RECYCLING REQUIREMENTS

A. Materials:

The following types of construction waste materials generated during the course of this project that are not salvaged shall be recycled:

THE FOLLOWING LIST INCLUDES EXAMPLES OF RECOVERABLE MATERIALS. MATERIALS OTHER THAN THOSE LISTED MAY ALSO BE RECYCLABLE. DUE TO VARIABLE MARKET CONDITIONS, THE SPECIFIER SHALL VERIFY THAT RECYCLING MARKETS FOR THE MATERIALS LISTED ARE AVAILABLE TO THE CONTRACTOR AT THE TIME OF BIDDING. THE RECYCLING MARKETS DIRECTORY PROVIDED IN THE AIA/HOUSTON CONSTRUCTION MATERIALS MANAGEMENT GUIDELINES MAY BE A USEFUL RESOURCE.

1. Concrete and concrete masonry products.
2. Asphaltic concrete pavement
3. Metals
4. Scrap dimensional lumber, broken crates and pallets.
5. Plastics
6. Brick
7. Cardboard
8. Gypsum board
9. Asphalt shingles
10. Paint containers

B. Methods:

The following recycling methods may be used:

1. On-site separation: Each material to be recycled is separated at the job site and delivered to the recycling markets or directly from the site.
2. Off-site separation: Materials to be recycled are delivered unsorted from the job site to a materials recovery facility or transfer station where recyclable materials are separated from other waste. If this method is selected, the Contractor shall verify that the entity responsible for the off-site separation has a market for all of the materials that are required to be recycled that it receives from the job site.
3. A combination of each of the above methods.

1.07 QUALITY ASSURANCE

- A. Accompanying each Application for Payment the Contractor shall furnish receipts from the recyclers, materials recovery facility or transfer station which identify the quantities and types of materials received from this project.
- B. Prior to final payment the Contractor shall complete and submit with other required project completion forms the Project Waste Management Record Form. This form shall identify actual quantities and types of waste recycled from this project and actual quantities of waste disposed of by other methods.

1.08 RESOURCES

- A. The "Construction Materials Management Guidelines", a publication of AIA/Houston for the Governor's Energy Office provides construction waste recycling economics worksheets, recycling market information and other related information that may be useful to the Contractor in estimating the construction waste quantities and recycling costs for this project. This publication is available from AIA/Houston (713) 662-2081.
- B. A directory of current construction waste recycling markets for the Houston area is available at AIA/Houston (713) 622-2081.

PART 2 - PRODUCTS

Not Used

PART 3 -EXECUTION

Not Used

END OF SECTION

Planning Worksheets

Choose the Best Waste Management Alternative for Your Project

First, from a purely financial perspective of construction waste, what is the most cost-effective means of managing the waste generated from a given project? Then consider the environmental, materials and project costs and benefits of traditional landfilling and recycling using either on-site separation or off-site separation methods.

Project Name		Location		Type	1. Interior 2. Exterior 3. Both
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Step I - Estimate Waste Quantities

1. Estimate the amount of waste for this project. For commercial projects add both interior and exterior components using the table on the left for the total waste generated. For houses, use the table on the right. In the absence of your own data, use the initial data for waste generated for your project type. As you implement materials and waste management plans, use the waste and cost figures from your experience in these tables.

Table 1.1-- Estimated Waste Quantities

Commercial				
Assumed waste per square foot - Exterior (from page 22)	X	Square feet of construction- Exterior	=	Estimated waste - Exterior
	x		=	
Assumed waste per square foot - Interior (from page 22)	X	Square feet of construction - Interior	=	Estimated waste - Interior
	x		=	
		Total estimated project waste	=	

Residential				
Assumed waste per square foot (from page 22)	X	Square feet of covered construction	=	Total estimated project waste
	x		=	

2. If the waste is to be sorted off-site for recycling or disposed of in a landfill, estimate the number of containers or truckloads to be filled and hauled. Round up to the nearest whole container or truck.

Table 1.2 -- Estimated Number of Large Containers or Trucks

Total estimated waste (from Table 1.1)	%	Container or truck size to be used	=	Estimated number of container loads
	%		=	

Step II - Estimate the Costs of Waste Disposal Alternatives

A. Landfilling

Estimate the cost of discarding all the waste at a landfill. Add the estimated container rental if the project is small and will not quickly fill a container.

Table II.A.1 -- Estimated Cost of Landfilling

	Container rental, \$/haul	+	Transport cost, \$/haul	+	Tipping cost, \$/haul (\$/yd times container size)	=	Total estimated landfilling cost/load	X	Estimated number of container loads (from Step I, Table 1.2)	=	Total estimated landfill cost for the project
Hauler/Landfill		+		+		=		X		=	\$
Hauler/Landfill		+		+		=		X		=	\$

B. Off-Site Separation

Estimate the cost of the off-site separation & recycling alternative. Since no waste is separated at the job site, the waste handling logistics are similar to the landfilling alternative, except the waste is delivered to a material separation and recovery facility. The cost may be different. Be sure to obtain quotes. For information on typical MRF requirements refer to Appendix I, Resources. Add the estimated container rental if the project is small and will not quickly fill a container.

Table II.B. 1 -- Estimated Cost of Off-Site Separation

	Container rental, \$/haul	+	Transport cost, \$/haul	+	Tipping cost, \$/haul (\$/yd times container size)	=	Total estimated off-site separation recycling cost/load	x	Estimated number of container loads (from Step I, Table 1.2)	=	Total estimated off-site separation recycling cost for the project
Hauler/ Separation site		+		+		=		x		=	\$
Hauler/ Separation Site		+		+		=		x		=	\$

C. On-Site Separation

On-site, or source, separation allows for more thorough recovery of recyclable materials. It requires more stacks or containers on the site. Small containers such as gaylord boxes can be used for some materials. The material recycler may quote container, hauling and tipping. For some materials you will be paid money or receive a credit toward hauling. More time will elapse before there is enough material to be worth transporting. Include container rental if necessary.

1. Estimate the number of containers to be filled and hauled for each material. Estimate the volume of each material from the tables on page 22. In the absence of your own data, you may use the initial data provided.

Table II.C.1 (a) Quantities of Commercial Exterior or Residential Waste

		Estimated Percent of total waste stream (from data tables on page 22)	X	Project Total estimated waste (from Table 1.1)	=	Amount of this material		Container size to be used	=	Estimated number of container loads
M	Metals		x		=				=	
C	Cardboard		x		=				=	
W	Wood		x		=				=	
P	Plastic		x		=				=	
B	Brick		x		=				=	
0	Other		x		=				=	
	Trash		x		=				=	
		100%								

Table II.C.1 (b) Quantities of Commercial Interior Waste

		Estimated Percent of total waste stream (from data tables on page 22)	X	Project Total estimated waste (from Table 1.1)	=	Amount of this material		Container size to be used	=	Estimated number of container loads
M	Metals		x		=				=	
C	Cardboard		x		=				=	
W	Wood		x		=				=	
P	Plastic		x		=				=	
B	Brick		x		=				=	
0	Other		x		=				=	
	Trash		x		=				=	
		100%								

2. Estimate the cost of on-site separation. Get quotes from different haulers and recyclers. (Refer to Appendix II). Just as you would for the traditional waste landfilling option, you will develop a list of recyclers from whom you will take quotes and with whom you will develop business relationships. You will develop your own preferred way of handling the materials and having them hauled. Materials could be laid on the ground in piles or in pens built quickly using old form lumber, placed in gay lord or other boxes (dishwasher and other appliance boxes work well), or renting drop boxes. Label the boxes. Cover corrugated boxes used for containers with a sheet of old plastic from the foundation finishing or from materials packaging, then when the materials are hauled for recycling, add that cover to the plastic box.

Table II.C.2 Combined Commercial Estimates (add interior and exterior), or Residential Estimates.

	Materials site-separated for recycling	Cost of container rental or purchase, \$/load		Cost of hauling, \$/load	+	Cost (+) or payment benefit (-) of tipping, \$/load (\$/lb times weight/load)*	=	Total cost per load per material	x	Estimated number of container loads (from Table II.C.1)	=	Total estimated costs
M	Metals		+		+		=		x		=	
C	Cardboard		+		+		=		x		=	
W	Wood		+		+		=		x		=	
P	Plastic		+		+		=		x		=	
B	Brick		+		+		=		x		=	
0	Other		+		+		=		x		=	

Landfilling the remaining trash			+		+		=		x		=	
---------------------------------	--	--	---	--	---	--	---	--	---	--	---	--

Hours of separation labor per pound of waste	x	Estimated total waste, lbs	x	Your cleanup personnel hourly rate, \$/hr	=	Estimated additional labor to separate on site
	x		x		=	

Total** estimated cost (-benefit) of on-site separation and recycling	=	\$
-----------------------------------------------------------------------	---	----

*Use the convention of costs being a positive number. Call benefits "negative", so they are subtracted from costs, and hence reduce cost.

** Add the costs (or benefits as negative), landfilling cost, and estimated labor for the total cost of this alternative. Add the individual materials recycling costs (or subtract the benefits), the cost to landfill the remaining non-recyclable trash, and the estimated cost of additional labor (based on the time required to separate the waste over the time it would ordinarily take to take the trash to the roll-off or other container).

Step III -- Compare the Total Cost of Waste Management Alternatives

This table guides the calculation of the total cost or benefit of recycling construction waste. The cost numbers on the previous pages are expressed as positive numbers. In this table, you will:

- ❖ Add the other cost of waste -- the money spent to buy it and have it delivered in the first place.
- ❖ Then take into consideration the benefits *of* recycling that are intangible such as public relations for your company, good will, a protected environment, reduced landfill consumption rates. (Subtract those benefits from the cost). In the case of landfilling, there are no benefits.

In the following table bring forward the total cost of the waste management and recycling alternatives developed in the preceding worksheets. Add the original cost of the materials you discarded (either by landfilling or recycling -- either way you had to pay for them). Then subtract the benefits of recycling.

Comparison of Waste Management Alternatives

	Waste Management Alternative Costs, \$	Landfill Only	Off-Site Separation Recycling	On-Site Separation Recycling
	Best Prices (from Step II A, Band C worksheets on previous pages)	\$	\$	\$
	Add the original purchase and overhead cost of construction materials discarded:			
+	Cost of Steel	+ \$	+ \$	+ \$
+	Cost of Wood	+ \$	+ \$	+ \$
+	Cost of Plastic	+ \$	+ \$	+ \$
+	Cost of Bricks	+ \$	+ \$	+ \$
+	Cost of Other	+ \$	+ \$	+ \$
	Take into consideration the intangible benefits of recycling. Subtract these:			
-	Value to the Company	0	- \$	- \$
-	Value to the Community	0	- \$	- \$
-	Value to the Environment	0	- \$	- \$
=	Real Cost of Waste	\$	\$	- \$

The values to the company, the community and the environment (and what ever other values your company may perceive) are totally subjective. The question is: "What is it worth to us to recycle?"

Section III: Implement and Improve

Waste Management Tracking

Making Progress

As your company implements new plans and practices for materials management and waste reduction, keep records of your success. Use the form on the following page to keep track of your success at reducing and recycling waste.

How to Use the Form

There are three sections to the form. The top section is for recording the transportation and destination of recycled materials. Metal, cardboard, wood, plastic and brick are listed because those are the readily recyclable materials in the current Houston area market.

The second section is to record data about the waste that is discarded, and the third section is to summarize the data regarding the total waste generated and managed.

As you execute the plan, hire haulers and deliver materials to recyclers and landfills, record the activities and the resulting costs or money earned. The form guides the summary of this information for plotting on the tracking graph.

Using Your Real Data to Plan

As you plan your first project using these guidelines, the starting data provided in this guidebook may be useful (see Appendix I). Then as you execute plans and gather quantity and cost data applicable to your projects, you can use that data to plan your next projects.

As you would do with any vendor, shop for the best recycling and disposal price and shop for the best transportation arrangements.

Using the Waste Management Tracking Graph

At the end of each project, plot the final information waste recycled, waste disposed of and waste on a square-foot basis.

$$\text{Recycled/Square Foot} = \frac{\text{Total Waste Recycled}}{\text{Square ft. of Construction}}$$

$$\text{Landfilled/Square Foot} = \frac{\text{Total Waste Produced}}{\text{Square ft. of Construction}}$$

$$\text{Total Waste/Square Foot} = \frac{\text{Total Waste Generated}}{\text{Square ft. of Construction}}$$

Figure 1 shows an example of what your graph would look like as your company and trades get better at reducing and recycling waste. The graph for you to use is on page 18. The data comes from the Waste Management Record on page 17.

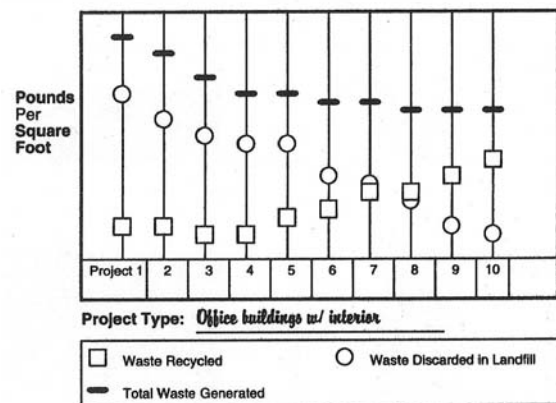


Figure 1. Example of a Waste Management Tracking Graph

Waste Management Record

Document the waste hauled from a worksite. Categorize the loads by materials if possible. Create your own form to accommodate more hauls or different materials. This will show your largest waste streams, allow you to plot waste reduction and recycling success, and assist you to assess and alter waste management practices.

Project	Construction
Size	<input type="checkbox"/> Interior <input type="checkbox"/> Exterior <input type="checkbox"/> Both

Material	Date	Oty - lbs	Oty - cu. yd	Hauler	Haul cost per	Haul cost, \$	Recycler or landfill for trash)	Recycle (or landfill) \$ cost/benefit (-)per-	Recycling (or landfilling) \$ cost/benefit (-)	Total waste handling \$cost / benefit (-) (haul + recycle)
Metal										
Metal										
Total Metal						\$			\$	\$
Cardboard										
Cardboard										
Total						\$			\$	\$
Cardboard										
Wood										
Wood										
Total Wood						\$			\$	\$
Plastic										
Plastic										
Total						\$			\$	\$
Plastic										
Brick										
Brick										
Total Brick						\$			\$	\$
Total Recycled Materials						\$			\$	\$
Trash										
Trash										
Total Trash						\$			\$	\$
Total Project						\$			\$	\$

Appendix I: Reference Data

Market Data: Initial and Ongoing

Initial Planning Data

To plan your first projects, you may use the following data that represents conditions (at press time) in the Houston hauling, recycling and landfilling markets. Hauling rates are not presented due to the large variations in quotes. Call for job-specific quotes.

Then, as you execute your new materials management and recycling plans and acquire data relevant to your type of projects, you should use that data to plan the next projects. You may use this following table to record waste management cost data for up-to-date planning.

Value or Cost of Materials Recycled or Discarded

Material	January, 1994 best sales value	January, 1994 best costs	Project 1: Date:	Project 2: Date:	Project 3: Date:	Project 4: Date:
Metal (steel)	\$0.03/ lb					
Corrugated cardboard	\$0.02/ lb					
Plastic	\$0/ lb					
Brick	\$0/ lb					
Carpet pad	\$0.20/ lb					
Wood		\$4.50/cu yd				
Trash		\$6.50/cu yd				
Other						
Hauling fee						
Container rental* -- 20 cu yd		\$4.00/day				
On-site separation time**		0.12 hr/ 1000lb				

* Container rental may not be charged if hauls are frequent. Call the haulers for more information.

** This the time required to separate the materials above the time it would have taken to get the materials to a trash container.

Waste Component Data: Initial and Ongoing

Waste Composition

The AIA demonstration program included measuring the various components in the waste streams from residential and commercial construction. The initial values in these lists are derived from the Program. From the charts below, apply the percentages of the various materials to the calculations of estimated quantities in Table 1.1 of Step 1.

For each of your projects, record the total amounts of each material recycled from your Waste Management Record on page 20. Record the individual material totals in the tables below. Thus you will develop your own data for the types of projects you build. Be sure to keep separate tables for similar structures.

Commercial Exterior Construction Waste Components*:

Waste Component	Initial Values, Lb/SF	Initial Values, % of Exterior Waste Stream	Project 1	Project 2	Project 3	Project 4
Metal (steel)	.52	11.4%				
Corru2ated Cardboard	.22	4.8				
Wood	.73	16.1				
Bricks (and mortar)	.77	17.1				
Plastic	.14	3.1				
Trash	2.16	47.4				

Commercial Interior Construction Waste Components*:

Waste Component	Initial Values, Lb/SF	Initial Values, % of Total Waste Stream	Project 1	Project 2	Project 3	Project 4
Metal (steel)	.068	5.9%				
Corru2ated Cardboard	.021	1.8				
Wood	.061	5.3				
Plastic	.012	1.0				
Trash	.98	85.9				

* The Brown & Root Recruiting Center on-site separation project provides the initial data in the commercial interior and exterior waste composition lists. The building was a single story, 20,000 SF steel structure w/ brick veneer. The interior was built out with separate offices, reception areas, kitchenette, bathroom and other areas.

House Construction Waste Components*:

Waste Component	Initial Values, Lb/SF	Initial Values, % of Total Waste Stream	Project 1	Project 2	Project 3	Project 4
Metals	.01	0.1%				
Cardboard	.19	1.5				
Wood	4.1	36.2				
Bricks (and concrete)	5.2	45.0				
Plastic	.004	.04				
Gypsum wallboard	1.21	10.5				
Shinszles	.03	.2				
Trash	.71	.06				

* Study houses provide the initial data in this list. The houses were common lot line, single story, wood structure with brick veneer averaged 2,636 SF. SF,

Single-Material Density

These figures may be used to estimate the volume of materials if they are placed by hand in a container (for on-site separation). Use the information to plan container or pen sizes to hold the separated materials. For cardboard and plastic, it assumes the materials have been flattened and pressed into the container or truck. For wood and metal it assumes most of the pieces are laid parallel. The figures for steel assume the waste is mixed metal studs and ducting with some rebar.

Material	Density if placed by hand in individual containers, lb/yd ³ (initial data)	Density calculated from your projects
Bricks	970	
Cardboard	91	
Metal (steel)	260	
Plastic	385	
Wood	410	
Trash	400 to 440	

Appendix II: Resources

Resources & Markets

Key to Materials Recycled

The letters in the following table are the key to the materials recycled by the companies listed in the following resource sections. Also included in this table are general comments about how the recyclers will receive the materials and in what condition.

Material	Typical Conditions
MRF Materials Recovery Facility	Accepts construction site waste stream unsorted. Generally will not accept large amounts of paving and concrete waste or dirt.
M Metals	Steel is the most common of the construction metals that make it to the containers. Soft drink aluminum cans are a minor contribution. Most metals recyclers want the different metals separated. You may be able to make other arrangements.
C Cardboard	Corrugated and craft paper: Corrugated, not paperbox type cardboard. Brown craft paper is acceptable, but not blueprint or other office type paper. Most will accept the staples and tape on the outside of the containers, but not the tape from the product's wrapping, nor plastic, styrofoam or other packing materials.
W Wood	Check with wood recovery facilities for restrictions on the type of wood products accepted. Pressure treated wood may not be acceptable at composting facilities. Composting facilities are especially particular about the quality of the loads -- metal (like nails) are usually acceptable.
P Plastic	The plastics market is the most unstable in the current recycling market complicated by the wide variety of plastics. Plastics recyclers are very picky about the quantities and types of plastics they accept

Material	Typical Conditions
B Brick	There are a few companies that recover unbroken used and new brick, and may come to the site and recover what they want without charge. Broken brick is accepted in few places.
F Flooring	Limited market for new or used carpet. You may be able to give larger pieces of carpet away to charitable organizations. Carpet padding is accepted at a couple places in the Houston area. It pays the highest price per pound of all the construction waste materials in today's market
A Asphalt, shingles	Asphalt shingles and asphalt are not yet recycled in this region, though they are in other parts of the country.
G Gypsum	Wallboard is not yet recycled in this part of the country, though it is in a few other regions. It could be recycled into new sheetrock, or prepared as a soil amendment for agricultural purposes.
O Other	Other recyclable materials that may be generated on the construction site include blueprints, specifications and other paper waste, glass and other items Recyclers for these are not listed due to the small quantities typically generated on site.

Working with a Recycler

Regardless of the facility to which you intend to take construction waste, you must call first to determine tipping fees or the amount they will pay you, and the condition of the materials they will accept. Recyclers are rarely licensed landfills as well. Their business is the material they collect and recycle, and anything else is a trash burden. So they are fairly strict about the quality of the loads they receive.

In the current Houston market (as it pertains to the recycling of construction waste), only metals and corrugated cardboard have any sales value. Plastic (and only certain types) can be delivered with little or no charge. Wood may be tipped at some wood recovery facilities for a fee slightly less than landfilling.

Most recyclers will accept materials only if they are source-separated: that is the materials have been placed in separate containers prior to their delivery to the recycler's facility.

Additionally, they generally accept only "100% quality materials" loads. A container or truckload of a given material cannot have other materials in it. Recyclers realize the materials may be "dirty" but they do not want dirt in the loads. Recycling requires a different frame of mind than what work crews are accustomed to when dealing with waste. The materials being handled are to be recovered, not simply thrown in a hole and buried. The materials don't need to be spotless, just not coated with mud.

A MRF is a Materials Recovery Facility. A MRF accepts materials unsorted. Be sure to call to determine any limitations on material types, the quality and other cost or income conditions of acceptance. Even a construction waste recycling program using the off-site recovery method (a MRF) needs to follow certain segregation rules like keeping lunch waste out of the container.

Recyclers in the Houston/Galveston Region

I. Multi-material Recyclers -- Commingled -- MRF's

These recyclers accept two or more materials mixed in a single container.

Material, condition, purchase, other comments	Company, Address	Contact & Phone	Provide container & ? Area Served
MRF Dry, non-hazardous. No food waste. No shingles, dirt, rubble. Call for arrangements. (Full service solid waste management)	WRS Recovery Center 100 Genoa-Red Bluff Road Houston, TX 77034	Dana Sanders, Sales Representative Ph: (713) 922-1000 Fax: (713)922-1474	Yes Houston/ Clear lake

II. Multi-material Recyclers -- Separate Containers

These recyclers accept two or more separated materials.

Material, condition, purchase, other comments	Company, Address	Contact & Phone	Provide container & haul? Area Served
C - 20 cu. yd. min. Corrugated only, no mixes. F - Carpet pad. No Carpet, no other contaminants. W - Any wood, 20 cu. yd. minimum. Clean.	American Refuse Inc. 6116 Cunningham Houston, TX 77041	Sylvia Silvas, General Mngr Pamela Piersol, Sales Mngr Ph: (713) 896-0433 Fax: (713) 896-8194	Yes. Houston, 50 mile radius

Material, condition, purchase, other comments	Company, Address	Contact & Phone	Provide container & haul? Area Served
<p>C - Corrugated. baled or placed in BPI container.</p> <p>M - Steel, aluminum, tin, bimetals. Any quantity or condition. No hazardous waste.</p> <p>P - HDPE and PET. Clean, no hazardous waste.</p>	BPI Industries 8101 Little York Road Houston, TX 77016	Chris Grant Ph: (713) 635-7777 Fax: (713) 635-7138	Yes. All Houston
<p>C- Corrugated, loose or baled, no hazardous waste. Purchased from hauler/generator.</p> <p>M - Purchase any metal, any quantity (metals can be mixed in the same container)</p> <p>W - Any brush and wood, uncontaminated. Rates for separated materials may be less than rates for commingled loads. Call for Quote.</p>	WRS Recovery Center 100 Genoa-Red Bluff Road Houston, TX 77034	Eric Heyne, Gen.Mngr. Dana Sanders, Sales Rep. Ph: (713) 922-1000 Fax: (713) 922-1474	Yes. Houston/ Clear Lake

Single-Material Recyclers

Also look in Multi-Material lists also for materials.

Corrugated Cardboard

Condition, other comments	Company, Address	Contact & Phone	Provide container & haul? Area Served
Corrugated, clean.	ACCO Waste Paper of Houston 403 Jennies Drive Houston, TX 77020	Larry Singer, Gen.Mngr Alan Baccarat, Sales Mngr. Ph: (713) 227-6541 Fax: (713) 229-9901	Call for container and pickup inf. Houston metro
Any condition, separated.	ASK Recyclers 4410 Pinemont Houston, TX 77018	Shari Walker, Owner Janet Robinson Ph: (713) 467-7972 Fax: (713)681-5824	No. Spring Branch, NW Houston
Corrugated and kraft paper. Must be flattened.	Environmental Recycle Plus 2222 Marnel Houston, TX 77055	Jesse Quiroz, Recycling Specialist Ph: (713) 461-9122	Yes. Houston metro
Any quantity.	Vista Fibers 1200 Brittmooore Houston, TX 77043	Dennis Elias, General Mngr Ph: (713) 461-9933 Fax: (713) 461-9937	Yes S.E. Texas
Corrugated cardboard, loose or compacted.	Waste Management Recycling 3228 Bennington Houston, TX 77093	Rob Paxton, Sales Manager Ph: (713) 695-4055 Fax: (713) 695-0948	Yes. Roll-off or dumpster. Greater Houston

Brick

Company, Address	Contact & Phone		Provide container & haul? Area Served
Any condition. No hazardous waste. Limited concrete. Call	Able Brick 9640 Telephone Road Houston, TX 77075	Berry Honeycutt, Pres. Ph: (713) 991-2790 Fax: (713) 991-7519	No. Receive from anywhere

Flooring

Condition, other comments	Company, Address	Contact & Phone	Provide container & haul? Area Served
Carpet padding (no rubber pads), Upholstery padding. New carpet - 2'x3' minimum. Used carpet - 40 yd min., good condition. These materials are purchased. Call for price.	CPR - Carpet Pad Recycling 8820 Hempstead Rd. Houston, TX 77008	Debbie Audas Steve Audas Ph: (713) 688-6621 Fax: (713) 680-8675	No.

Metal

Condition, other comments	Company, Address	Contact & Phone	Provide container & haul? Area Served
Non-ferrous. Any quantity. Scrap. Buy Aluminum cans.	A-I Iron & Metal Company, Inc. 306 S. Jensen Houston, TX 77003-1116	Sandra Lusky, Owner Ph: (713) 225-5720 Fax: (713)237-9066	Yes. Houston metro
Copper, brass, aluminum, and stainless steel. Any condition, any quantity. No hazardous waste.	AB&C Recycling Center 1523 Wilde Rock Houston, TX 77018	Linda & Chuck Crull Ph: (713) 861-7575 Fax: (713) 861-5005	Yes. 100 mile radius
Non-ferrous. Clean, no screws and no hazardous waste.	Ace Scrap Metal Recycling 6206 Long Drive Houston, TX 77087	Charlie Laviage Ronnie Laviage Ph: (713) 643-9922 Fax: (713) 643-2722	Yes. Houston
Non-ferrous. Any condition or quantity, no hazardous waste.	Allied Scrap Metals, Inc. 3311 Clinton Drive Houston, TX 77020	Larry or Alan Reichstein Ph: (713) 222-0479	Yes. Houston area.
Non-ferrous. Any condition, any amount, no hazardous waste. Will take electronic scraps.	Altech Metals Inc. 10612 - A Hempstead Highway Houston, TX 77092	Bryan Frazar Ph: (713) 680-9325 Fax: (713) 680-3519	Yes. Houston metro
Copper, brass, aluminum, stainless steel. Any condition and quantity.	C&D Scrap Metal Recyclers Co. Inc. 815 W. 25 Houston, TX 77008	Dennis Laviage, Pres. Jeff Johnson, VP Ph: (713) 862-5588 Fax: (713) 862-4316	Yes. Houston, 50 mile radius

Copper, tin, lead. (also catalytic converters). 1,000 lbs minimum. No hazardous waste.	Chemetco- Houston 415 North Wayside Houston, TX 77020	Lynn Mabry, Manager Ph: (713) 678-7171	Yes. Houston metro area
Iron, brass, copper, stainless. Separated into ferrous and non-ferrous, clean.	Commercial Metals Co. 2015 Quitman Houston, TX 77026	Chock Yates, Plant Manager Bernie Sugar, Buyer Ph: (713) 228-7411 Fax: (713) 228-8098	Yes. Houston metro
Brass, copper, aluminum. Any condition and quantity. No hazardous waste.	Cribbs Recycling 10705 Bauman Houston, TX 77076	Harold Cribbs Steve Sowda Ph: (713) 694-5882	Yes- containers No haul. N. Houston
Ferrous & Non-ferrous. Any quantity and condition. No hazardous waste.	Greater Texas Metal Recycling Company 1211 College South Houston, TX 77587	Marak Edelheit, Pres. Ph: (713) 943-8596	Yes. All Houston
All metals. Prefer large quantities. Any condition. No hazardous waste	Gulf Coast Scrap Metal 9449 Briar Forest Houston, TX 77077	Joel or Mike Ph: (713) 226-9931	Yes. Texas gulf coast.
Steel and non-ferrous. Clean and separated. Any quantity.	Houston Refuse Disposal, Inc. 7414 Wingate Houston, TX 77011	Mike Boyd, President Ph: (713) 923-4385 Fax: (713) 924-3020	Yes. Houston, Galveston
Ferrous and non-ferrous. Any amount and any condition. No hazardous waste.	J&L Metals 7319 Long Drive Houston, TX 77097	Joe Schneider, Owner Ph: (713) 644-9992 Fax: (713) 644-7200	Yes. Houston & surrounding areas.
Ferrous & non-ferrous, large and small. No hazardous waste.	Musselwhite Metal Corp. 8202 West Montgomery Road Houston, TX 77088	Ron Musselwhite, Owner Ph: (713) 445-1132 Fax: (713) 448-2844	Yes. Houston & surrounding areas
Ferrous & non-ferrous. Any amount and condition, no hazardous waste.	Otwell Recycling 1809 Preston Houston, TX 77503	Jim Otwell, Owner Ph: (713) 472-5722	Yes. 50 miles
Ferrous & non-ferrous. Truck load minimum. Any condition. No hazardous waste.	Proler Metal Processing 7501 Wallisville Road Houston, TX 77020	Jerry Bailey, Rgnl.Mngr. Ph: (713) 675-2281 Fax: (713) 671-5907	Yes. 150 mile radius

Wood

Condition, other comments	Company, Address	Contact & Phone	Provide container & haul? Area Served
Any brush and wood, any quantity.	Gower Construction Co. 12622 Boudreaux Tomball, TX 77375	Richard Gower, President Lori Bryant Ph: (713) 351-6603 Fax: (713) 255-8419	Yes. Houston area

III. Haulers

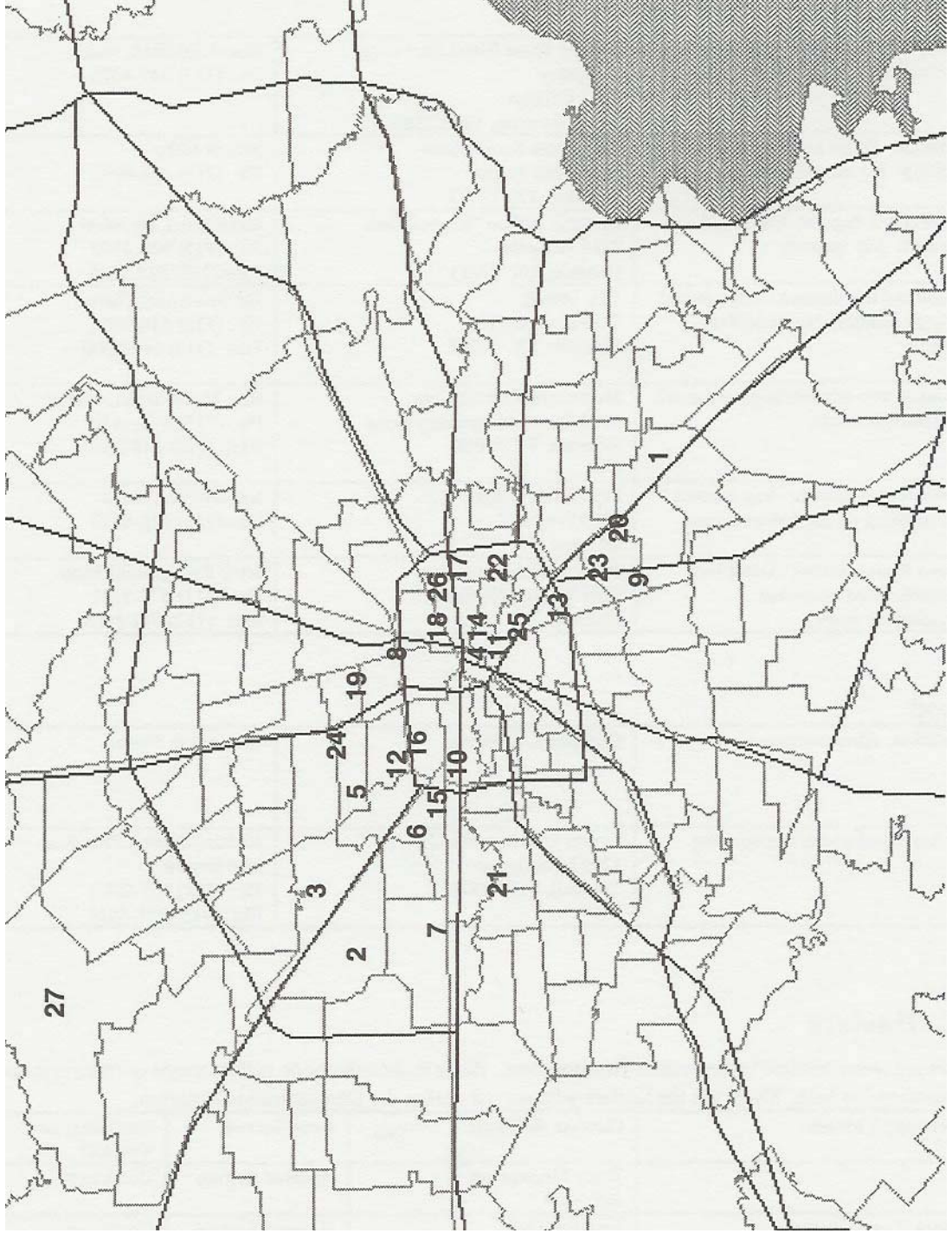
There are many haulers in the greater Houston area. Refer to the telephone yellow pages or other resources for more comprehensive lists. These are the haulers who served during the Demonstration Program.

Company, Address	Contact & Phone	Area Served	Container or Trucks?
BPI	Tracy Mesenbrink 461-1444	Houston Region	Containers
Custom Waste Control	Juan De Amda 237-0078	Houston Region	Containers
Goodwill Construction Services	Juan Pupo 492-7690	West Houston	Trucks
R.C. Contracting Services	Roy Conner 747-2014	Houston Region	Trucks
Roadrunner Construction Services	Clyde Cebrat 452-6727	Southeast Houston	Trucks with grapples
WRS	Eric Heyne 922-1000	Houston/Clear	Containers
Waste Management of Houston	Greg Million 695-4055	Houston Region	Containers

Recycler Locations

Locate the recyclers near your project, then look them up in the directory. Also add to this map as you find more recyclers. Use this map to plan hauling logistics.

- 1 - WRS
- 2- American Refuse
- 3- BPI Industries
- 4- ACCO Waste Paper
- 5- ASK Recyclers
- 6 - Environmental Recycle Plus
- 7 - Vista Fibers
- 8 - Waste Management Recycling
- 9- Able Brick
- 10 - Carpet Pad Recycling
- 11 - A-I Iron & Metal
- 12 - AB&C Recycling Center
- 13 - Ace Scrap Metal Recycling
- 14 - Allied Scrap Metals
- 15 - Altech Metals
- 16 - C&D Scrap Metal Recyclers
- 17 - Chemetco-Houston
- 18 - Commercial Metals Co.
- 19 - Cribbs Recycling
- 20 - Greater Texas Metal Recycling
- 21 - Gulf Coast Scrap Metal
- 22 - Houston Refuse Disposal
- 23 - J&L Metals
- 24 - Musselwhite Metal Corp.
- 25 - Otwell Recycling
- 26 - Proler Metal Recycling
- 27 - Gower Construction Co.



Appendix III: Background

The Recycling Demonstration Program

The Program

The AIA Construction Materials Recycling Demonstration Program was conducted by AIA Houston under a grant administered by the Texas Governor's Energy Office. On-site and off-site separation and recycling demonstrations of construction waste materials were conducted at commercial and residential construction sites. Additionally, information about the typical handling of waste and its landfilling was gathered through interviews.

Owners, developers and builders allowed the program team to dictate how waste would be managed on their Houston-area projects. Contractors followed the new procedures. Construction waste haulers, not accustomed to hauling materials for recycling took the materials to recyclers who were not accustomed to receiving waste from construction sites.

The professionals who volunteer their projects for the demonstration were genuinely interested in the environment as well as cost effectiveness. And once involved, they were amazed at the amount of the various materials typically wasted and how much was recycled, experienced waste reduction, reused materials, and actually altered construction practices.

As the demonstration program progressed and it was observed as an experiment, the AIA program team was reminded of human behavior principles such as a desire for continuity and resistance to change. These were evidenced by statements such as "we've never done it before" and "I don't think it'll save us any money." The first statement may be true for you as is it is for most construction people. The second statement is site specific and depends how the materials are managed.

Observations and Lessons Learned

- ❖ A master plan for a project's materials management could be effective in reducing construction cost and protecting the environment.

- ❖ Prevention of waste generation by optimum materials planning and use is the most valuable step of a series of materials management practices. In this order of effectiveness, these practices can lead to better project economy and ecology:
 - Review
 - Reduce
 - Reuse
 - Recycle
- ❖ There are markets in the Houston region to recycle metals, cardboard, wood, some plastic and certain pallets.
- ❖ Recycling just metal, cardboard, wood and plastic from construction waste could reduce our region's landfill burden by about 5%. Getting rigorous and keeping brick, dirt and rubble, gypsum board and asphalt shingles (if there were recyclers in Houston for gypsum and asphalt) out of the landfill-destined loads could reduce the burden by nearly 15%.
- ❖ Leadership is required to have a construction waste recycling project be successful, since the workers in the industry are not accustomed to doing it. The workers need to be reminded of the procedures. Management needs to let everyone know it is serious about waste reduction and recycling.

The Demonstrations

Two projects provided data on which a great deal of information was gained, including the "initial values" in these guidelines. involved in the demonstration and one submitted waste data.

On-site Separation.

Brown & Root, Inc., Recruiting Center at Hirsch and Clinton. The 20,000 SF building involved both the shell and interior buildout. The waste from each part was distinguished.

A total of 114,060 lbs of waste was generated. Overall, 31 % of it was recycled. Approximately 35% of the waste from the exterior construction (including electrical, lighting and mechanical) was recycled. Only about 14% of the waste from the interior buildout (ceiling tiles, flooring, partitions and finish) was recycled. Metal (steel), wood, cardboard and plastic were separated from the waste and segregated in their own piles in a waste collection area (adjacent to the usual drop box).

The specific results of this project are used as the commercial construction "Initial Data" in Appendix I, Composition of Construction Waste for interior and exterior construction of commercial projects.

Off-site Separation

Two houses in Village Builders' Brookwood subdivision in Clear Lake were the subject of the off-site separation method. The waste was collected from around two houses in the typical manner, but was placed in a 30 yd container on the street. The full container was hauled 5 times by WRS to their MRF (materials recovery facility).

At the MRF, the waste was sorted into several material categories to provide data for the demonstration program, then the recyclables were recovered. the market at the time allowed for only wood, cardboard and metals to be recovered for recycling.

The specific results of this project are used as the residential construction "Initial Data" in Appendix I, Composition of Construction Waste.