Guide for Construction Waste Audits

May 1999

Prepared for:

Resource Efficiency Unit, Auckland Regional Council

Chris J Patterson, Project Facilitator

PO Box 67-040, Mt Eden, Auckland

<u>Contents</u>

Introduction

Why do a waste audit?

- to identify what types of material are being wasted
- to estimate the quantities of waste materials
- to assess the potential for waste reduction.

Reducing waste can save money, increase profits and divert waste from landfills.

Waste audit process

Waste audits are a tool for measuring the composition of the waste arising from construction activities and thus a means of estimating the quantities of waste materials.

The key steps in conducting a waste audit are:

- identify how and where waste leaves the site - the waste streams
- estimate the quantity of waste - typically for the audit period or over a year
- plan the audit in terms of the waste streams to be audited, the information required from the audit and the on-site audit arrangements
- set up on site and sort, weigh and record the weights of each material
- analyse the detailed data to give estimates of the waste composition and the overall quantities of particular materials if practical.

Assessing waste reduction potential

The potential for waste reduction can be assessed in two ways:

- by identifying ways of reducing each type of waste and then calculating the effect of applying these to the estimated quantities from the audit
- targeting the largest material components and seeking out or developing ways to divert this waste from disposal.

In most situations a mix of both approaches should be considered using the waste reduction hierarchy, avoid / reduce / reuse / recycle, to set priorities.

Construction considerations

The characteristics of many construction projects - a “one-off” design, constructed using a variety of materials that change as the job progresses, by a group of workers and sub-contractors that may not have worked together before - present particular challenges when waste audits are used to assess waste compositions.

This guide, prepared as part of the REBRI project, aims to provide practical assistance to firms addressing waste and waste reduction within the construction industry.

Waste Audit Process

Quantifying the waste streams

To quantify the waste[1] arising from a construction site:

1/ Identify all the ways waste leaves a site, ie. the waste streams[2].

This will involve:

- locating all the bins or skips on site; by walking round or by checking with the manager responsible for waste
- walking around the site to identify other means of disposing of waste, eg. council bins, on-site burning, plus any "firewood pile" and recycling collections
- monitoring the waste streams to identify any differences as the stage of construction changes
- making a visual assessment of the main materials in each waste stream
- confirming that waste associated with all the main materials being used on-site is represented in the waste streams identified.

This process is also an opportunity to identify waste reduction opportunities; eg. unnecessary waste, high cost materials, reusable items and materials that may be set aside for recycling.

Depending on the scope of the audit, the waste streams considered may also include concrete or other materials hosed down the drain, subcontractors taking away their own waste and rubble and spoil removed by demolition and excavation contractors.

2/ Estimate the quantity of waste for each waste stream.

Waste is normally measured in tonnes. This will involve:

- determining the frequency of collection
- determining the weight of waste collected
- using this data to estimate the waste collected over the study period, eg. one week, month
  - invoices from the waste contractor should provide the number of collections and will often show the weight collected

---

[1] The glossary of the REBRI Resource Guide defines construction site waste as any product or material resulting from the construction or demolition process that is surplus to, or not included in the finished building. [Available from the Resource Efficiency Unit, Auckland Regional Council.]

[2] Waste stream is a general term representing any collection or disposal method that results in waste materials leaving the site, including those collected for recycling.

- if bin weights are not available a recent study[3] suggests on average a 9 m^3 bin contains 1.39 tonnes of construction waste.
  (A table of average bin weights for different types of construction is given in Appendix 1.)

- aggregating the quantities for all the waste streams will provide an estimate of the overall quantity of waste arising from the project during the study period.

Note: Since the activities on a construction site change as the project progresses, the quantity of the associated waste may also change. Thus collecting waste data over a short period can only provide a "snapshot" of the waste arising from the work done during the study period. To get a picture of the overall quantities of waste arising during the construction of a complete building a series of studies at different stages of the project is required.

[3] Report on Sorting Trial of Construction Bin Waste, July 1997, Chris J Patterson, available from Resource Efficiency Unit, Auckland Regional Council

Planning the waste audit

The steps in planning a waste audit are:

1/ Select the waste streams to be audited.

Priorities should be:

- the major waste streams by weight (as identified when quantifying the waste streams as outlined above)
- waste streams with potential for waste reduction
- waste streams where the cost of disposal is high, eg. hazardous materials.

For most sites auditing the main waste bins will provide an initial picture of the waste composition for the project during the study period.

2/ Select the method for measuring the waste.

The options are:

- sort and weigh the entire contents of each bin

  This method provides an accurate breakdown, by weight, of the contents of the bin and a measure of the total weight of the bin contents.

  It is the most time consuming method but does not suffer from potential errors due to only a portion of the waste in the bin being sampled.

- sort and weigh a sample from the bin

  By only processing a sample of the bin contents this method reduces the work load. However, this introduces two problems; the need to take a representative sample from the bin and the need to establish the total weight of the bin contents.

- visual assessment of the composition of the bin waste

  While this method requires minimal effort it also requires the observer to make allowance for materials of different density (concrete versus cardboard) and different levels of packing (rubble versus lengths of timber). Visual assessment also requires judgement on any material hidden below upper layers of waste and an estimate or assumption on the weight of the waste in the bin. A set of volume to weight conversion factors for common construction materials is provided in Appendix 1.

The full sort and weigh method is the preferred method, unless the audit situation allows a reliable sampling procedure to be used and for the total weight of bin contents to be determined. The logistics of sorting construction bin waste are discussed later in the section Sorting logistics, construction bin waste, page 17.

3/ Determine a framework for selecting the bins to be audited.

An important consideration when determining which bins to include in an audit of construction waste is that each bin should be treated as a "snapshot" of the project waste rather than a representative sample.

The reason being that the main materials used on a construction site vary depending on the stage of the project, thus the resulting waste can also be expected to change as work progresses. This is a marked contrast to waste from a manufacturer or retailer where changes in the waste composition, week to week, are not likely to be very great.

The scale of the project will also affect the significance of this problem. For a small project such as a house, one bin of waste may arise from many stages of the construction and represent a large portion of the total waste for the project. Whereas for a high rise building generating many bins of waste a week, bins from different floors may contain waste from different stages of construction, for example lower floors may be being fitted out while the upper floors are being closed in.

The "snapshots" obtained from site based audits of construction waste can be a useful lead-in to waste reduction initiatives by providing an initial picture of the types of waste being generated. However, the results must be used and interpreted with caution, particularly when comparing projects, estimating the overall composition of the waste for a project or considering the logistics of proposed waste reduction activities.

The value of these "snapshot" audits of construction bin waste can be enhanced by carefully documenting how they fit into the overall waste picture for the project, ie. by putting them into context within the framework of waste collection for the project.

A number of steps can be taken during site based audits of construction waste to address these issues and to facilitate the sound use of the data obtained:

- where practical audit a complete project or a representative section of it, eg. one floor of a high rise, the fitout of one apartment out of a block
- document the context of each bin audited:
  - an estimate of how long the bin took to fill, ie. the time since it was put in place
  - the stage of construction and the main types of work that occurred while the bin was in position
  - for larger projects, the location of the bin or the area of the site it served
  - the number (and weight if possible) of other bins taken from the site during the audit period
  - any other information that may assist in interpreting the audit results and understanding the background to and the causes of the waste.

- obtain information about the project as a whole
  - collect information on the overall quantity of waste taken from the site; project accounts should provide invoices from the waste contractor for all bins collected
  - record when each bin was taken and the weight, if available, to provide a week by week picture of the waste for the project
  - prepare a timeline for the project that shows the timing of the main construction activities, eg. foundations, structure, cladding etc.
  - note the main types of construction and materials used; eg. timber frame, precast concrete, structural steel etc.

With care this background information can be used to put the results of individual bin audits into context within the overall waste picture for the project, or to make comparisons with other projects.

4/ Select waste categories for use in the audit.

The choice of the waste categories will depend on the purpose of the audit, the resources available for the audit and the amount of information available from earlier audits. Typically this will involve striking a balance between the accuracy required and the number of different materials for which composition data is required.

As a general rule, the more detailed the material breakdown, the smaller the proportion of waste in each category, and the less weight that should be placed on the individual results. Where practical and where resources permit, this can be offset by taking a bigger sample, either by auditing several bins and combining the results or by auditing a larger proportion of the waste stream.

Information from earlier audits may be used to select a limited number of materials for more detailed investigation. This should reduce the work involved in carrying out the audit and may allowing a larger sample to be achieved.

The section Sorting categories for construction and demolition waste, page 12, provides two basic sets of categories and a full discussion of sorting issues.

5/ On-site arrangements for audit

Sorting and weighing construction waste in any meaningful quantity is a significant materials handling exercise and needs careful planning to be effective. The typical $9m^3$ bin may contain up to 3 tonne of waste of all shapes and sizes.

The basic requirements are:

- a sorting area large enough to accommodate the bin being sorted, a bin for the sorted waste, a tipping area for the waste, the sorting containers (these may be

cartons, 240 litre wheelie bins or larger bins), and a space for weighing and recording
Figure 1 shows a typical layout for conducting a waste audit.

- a sheltered situation (to avoid waste being blown about in the wind) and covered if possible, with easy access for bin handling
- a safe position out of the way of regular construction and delivery activities
- a flat area about the size of a double truck bay, preferably sealed or concrete
- sorting containers and weighing equipment; two configurations that have been used are:

  - sorting into cartons and 240 litre wheelie bins using scales of 300 kg capacity
  - sorting into 240 litre bins and larger bins using a platform scale of several tonnes capacity, plus access to a forklift for handling the larger bins

- coordination and liaison with the waste contractor to allow “full” bins to be audited before they are removed for disposal.

The above requirements are based on sorting and weighing waste from full bins that are ready for collection. This is an easy and reliable method of auditing waste without disrupting normal work practices.

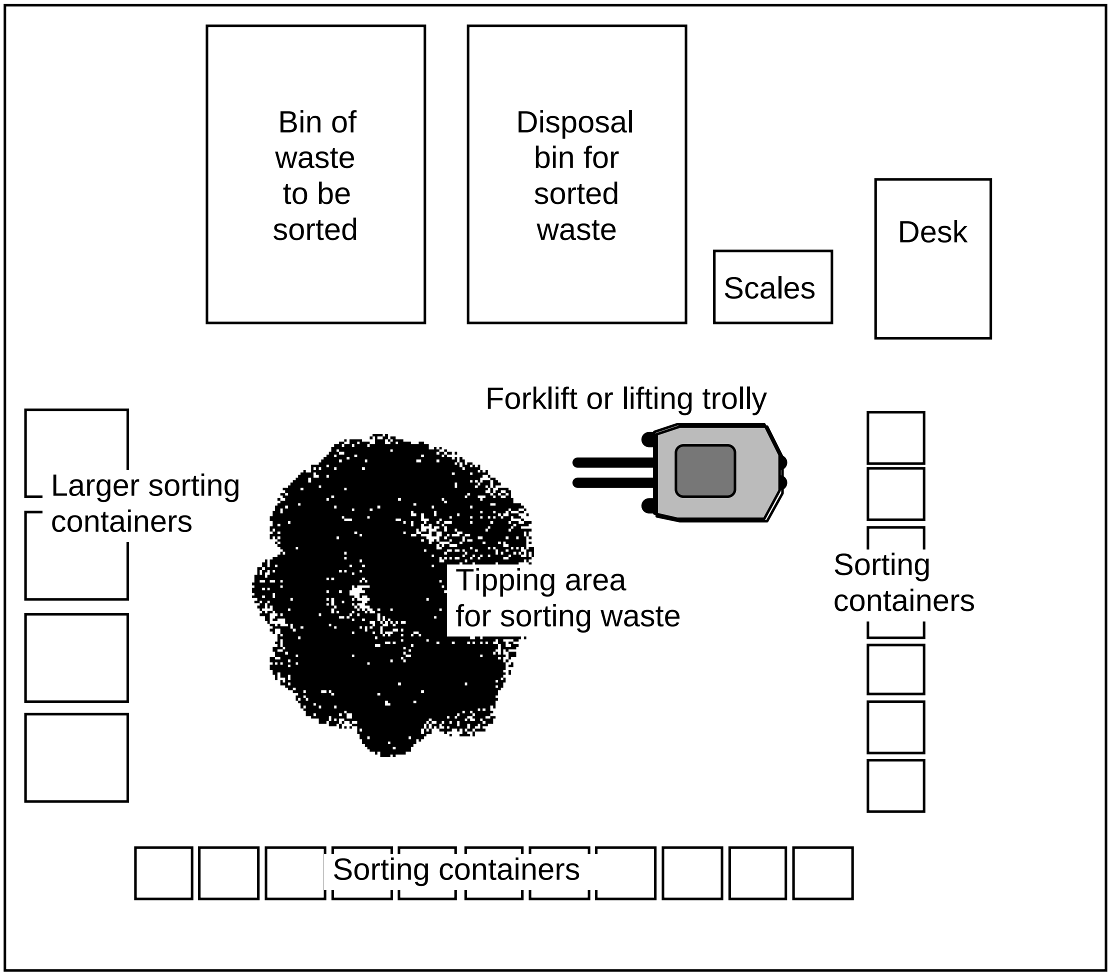

Figure 1 Typical layout for sorting area

Many other auditing approaches are possible and may be more suitable for particular situations, eg. accumulating waste from a particular area or activity, sorting and weighing the waste as it is put into the bin, doing the sorting and weighing off-site.

Figure 2 shows a layout used to conduct audits on a floor by floor basis in a high rise building. Arrangements were made to accumulate the waste near the waste chute so that it can be sorted and weighed periodically before being dumped into the waste chute.

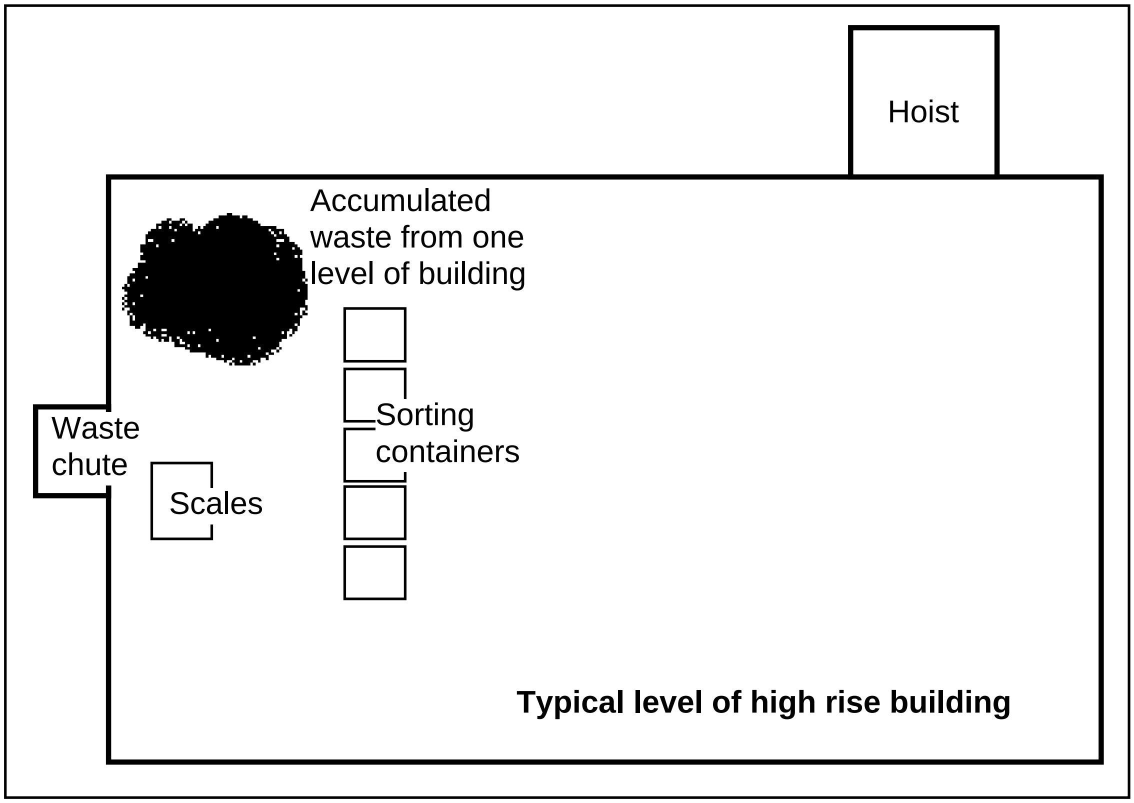

Figure 2 Layout used in waste audit of a high rise building

Conducting the waste audit

The steps in conducting a waste audit are:

1/ Sort and weigh each bin of waste

- sort the materials from the bin into the labelled sorting containers; at the end collect up the remainder, typically a mix of materials such as small offcuts, sawdust, nails, gravel & dust, and add to the "Mixed/other timber" category. (Refer to Table 1, page 13, for suggested sorting categories.)
- weigh each sorting container, full and empty, to get the weight of the waste material, record this on the audit worksheet. (See sample in Appendix 1).
- empty the weighed material into the waste bin for disposal
- repeat this process for each audited bin.

2/ Process the audit results

- aggregate <u>material weights</u> from similar bins, if required to provide totals where the audit involves more than one bin, eg. bins from the same stage of construction or all the bins for a whole project.
- calculate the waste composition as a percentage, based on the audit totals; average weights per bin may also be calculated.

Note: Where data from more than 5 bins is aggregated it may be useful to calculate the mean and standard error for the waste components as an indication of the variability in the waste composition.

3/ Extrapolation from audit results

Given the changing patterns of waste during the construction process the opportunities to make valid extrapolations from a few bin audits is limited.

To have some validity an extrapolation must be based on some rational quantitative assumptions about the waste generation process. Possibilities are:

- where only a sample of representative bins is audited and the corresponding total number of bins is known, the results may be scaled based on the proportion of bins sampled (by number or by weight)
- audit results from a small project, eg. a kitset house, might be scaled by the number of houses built in a year to give an annual estimate
- in a high rise project, audit results from one floor might be scaled by the number of floors to provide a overall estimate for that aspect of the project.

- “waste rates” based on floor area or wall area, eg. kg/m^2, may provide a way of generalising audit results that only cover a portion of the works.

Note: **Percentage compositions cannot be added across different audits** - this effectively “averages the percentages” which is not valid. Whenever data from different audits is to be added together, eg. for different stages of construction, a weighting process must be used[4].

Where extrapolated estimates are available it becomes possible to prepare estimates of the cost of waste (per week, for a project or over a year), based on:

- the cost of wasted materials, ie. their weight times purchase price
- waste handling costs, eg. the cost of staff involved full or part time
- the direct cost of waste, ie. the transport and disposal costs.

[4] To add together results from different audits, eg. from different stages of the project, the weight of each material for each stage must be calculated based on the total weight for its stage and these added to provide overall totals. These overall totals can then be used to calculate percentage compositions for the project as a whole. In statistical terms this calculates a weighted average of the audit compositions.

Sorting categories for construction and demolition waste

Sorting categories are used during a waste audit to sort and classify waste materials before weighing them. Typically nine primary categories are used - these may be subdivided to provide a more detailed breakdown of the waste.

The Waste Analysis Protocol[5] (WAP) provides a standard set of categories widely used in New Zealand, the primary categories are:

1. Paper;	eg.	newspaper, office paper, corrugated cardboard
2. Plastic;	eg.	soft drink bottles, PVC sheets, polystyrene foam
3. Glass;	eg.	bottles and jars, window glass
4. Metal;	eg.	steel cans, roofing iron, appliances
5. Organic;	eg.	kitchen scraps, weeds & tree branches, soil & clay
6. Rubble, concrete etc.	eg.	brick, rock, asphalt, gib board, fibrolite, fibreglass
7. Timber;	eg.	framing, planks, pallets, window frames, plywood
8. Rubber and textiles	eg.	tyres, piping, mats, rags, carpet
9. Potentially hazardous	eg.	solvents, paints, oil & grease, glues and empty containers from these.

While construction waste can include materials from all categories, the main components (by weight) are typically[6]:

Rubble, concrete etc.	**40-45%,**
	20-25% concrete & cleanfill
	10-15% plasterboard
Timber	**30-35%,**
	20-25% timber framing, planks & pallets
	10% plywood, particle board, MDF etc.
Metal	**6%**

---

[5] The Waste Analysis Protocol published by the Ministry for the Environment (Nov 1992) sets out procedures for measuring the composition of solid waste including standard categories for waste audits. Note: The categories used in this guide are the revised waste categories, distributed as an update in 1998.

[6] Based on the results of REBRI studies of construction waste in the Auckland Region in 1995 & 1997. [Study reports are available from the Resource Efficiency Unit, Auckland Regional Council.]

The sorting categories used in a waste audit should:

- provide a relevant breakdown of the main components of construction waste, ie. “Rubble, concrete etc.”, “Timber” and “Metal”
- reflect potential waste reduction opportunities, eg. recovery of metals, reuse of timber
- be detailed enough to obtain data on all the different materials of interest, but not so many that the accuracy of results is compromised.
- provide quantitative data on the make up of the waste that can be used in the development of waste reduction programmes
- make effective use of the time and resources available for conducting the audits.

Table 1 below contains two sets of suggested categories for use in audits of construction waste. They are defined within the framework of the primary and secondary WAP categories.

Appendix 2 provides details of the make up of the categories including examples.

To assist in determining where a particular waste item belongs, an alphabetical list of items is provided in Appendix 2 with the appropriate waste classification.

The first set of secondary categories is intended for “1st Cut” audits at the start of a waste reduction program when little is known about the waste composition. The 22 "1st Cut" categories provide a full breakdown of the main construction materials, Timber and Rubble, concrete etc. with only limited sorting of other materials.

The second set of categories is intended for follow-up audits where the broad composition of the waste is known. The 27 "2nd Cut" categories provide a full breakdown of the main construction materials plus a more detailed breakdown of other waste materials commonly arising from construction activities.

It is recommended that the total number of categories used is no more than 30. It is also recommended that where a category accounts for less than 5% of the waste the audit results should be considered as indicative only, unless the accuracy of the results can be calculated from multiple samples or audits.

The suggested categories may be expanded or combined for particular purposes. For example a project investigating opportunities for reducing timber waste might use a waste audit to identify the causes of timber waste by using a detailed breakdown of the "Timber, lengths & pieces" category. To save time all the other materials might be sorted and weighed as one category - "Mixed materials".

PRIMARY (WAP)	SECONDARY 1st Cut	SECONDARY 2nd Cut
1. Paper	Cardboard packaging Mixed papers	Cardboard packaging Building papers Mixed papers
2. Plastic	All plastics	- - Construction plastics Plastic film Mixed plastics
3. Glass	All glass	All glass
4. Metal	Mixed metals Multi-material/other metal	- - Mixed ferrous Mixed non-ferrous Multi-material/other metal
5. Organic	Soil & clay Mixed organic	Soil & clay Mixed organic
6. Rubble, concrete etc.	Rubble and rocks Concrete Plasterboard Fibre cement products Fibreglass Other	Rubble and rocks Concrete Plasterboard Fibre cement products Fibreglass Other
7. Timber	Length and pieces Pallets & crates Fabricated Sheets Mixed/other timber[7]	Length and pieces Pallets & crates Fabricated Sheets Mixed/other timber
8. Rubber and textiles	 All rubber & textiles	Carpet & underlay Mixed rubber & textiles
9. Potentially hazardous	Empty containers Untreated hazardous waste	Empty containers Untreated hazardous waste

Table 1 Suggested sorting categories for construction waste

To facilitate the comparison of audit results with waste composition data from other studies it is important to define the categories used within the framework of the standard WAP categories. The term "Mixed…" can be used to identify aggregate categories that cover several standard categories. The categories "Mixed papers" and "Mixed plastics"

[7] This "Mixed/other timber" category is an aggregate of the WAP categories "Sawdust/shavings" and "Debris/other timber" along with the mix of materials that remains at the end of the sorting process.

in Table 1 are examples of this convention, both represent aggregates of the standard WAP categories.

The categories in Table 1 do not distinguish between recoverable materials (by reuse, recycling etc.) and those that cannot be recovered. This determination depends on the available outlets for recovered materials and thus changes over time and for different locations. The potential for recovering materials and thus waste reduction can be determined by applying appropriate local recovery factors to each category used in the waste audit. This process is discussed in the section Assessing waste reduction potential on page 18.

Additional breakdowns

For some audits additional breakdowns of selected categories may be useful:

By "Cause" to identify the "cause" of the waste. This may be appropriate where there is a limited range of waste materials, eg. during framing or gib fixing.

One or more of the following might be used to subdivide secondary categories[8]:

Off-cuts	a major component for any cut-to-size materials, eg. timber, tiles, wiring, gib board
Rework	waste resulting from correcting errors or from making good rejected work
Temporary	eg. formwork, supports, jigs etc.
Protection	eg. plastic over carpets, paper from spray painting
Packaging	eg. cardboard, plastic wrap, pallets
Surplus materials	eg. plaster left overs, reinforcing ties, unused timber
Damaged materials	waste resulting from goods or materials damaged during delivery or handling on site.

By "Trade" to identify which trades are generating waste during busy stages of the project such as finishing and fitout, eg. painter, electrician, tilers.

NOTE:
1. It is usually wise to include an "Other" category to accommodate causes or trades that are not covered by the additional categories being used.
2. Different "cause" and "trade" categories may be used for different materials, eg. timber waste might use off-cuts, rework and other as causes while paper waste might be categorised by trade in the same audit.

---

[8] These "causes" were used to investigate the generation of construction waste in the first REBRI project, "Preliminary Investigation of Construction Waste in the Auckland Region", July 1995, Auckland Regional Council.

Sorting protocol - Classification conventions

1. Once the categories have been determined, the main problem is classifying items that contain more than one base material (composites) or items that contain potentially hazardous wastes. When sorting, the following rules should apply:

   Items with composite materials:

   - separate materials into the appropriate categories (eg. cardboard box of waste from electrical 2nd fix - separate the cardboard, plastic and wiring off-cuts);
   - if materials cannot be separated easily, the heaviest component of the waste determines the category;

     Examples:

     a piece of timber with nails in it would be classified as timber

     a metal shower base with wood attached would be classified as metal

     electrical wiring should be classified as metal.

   - if materials cannot be separated (or are contaminated with another material) and the composite waste is combined with either paper, plastic, glass, metal, or timber as the heaviest component, then the item is placed in a "mixed" or "other" category. The reason for this is that additional materials may complicate recycling or recovery.

     Example:

     old boxing would go into “Timber” because it is the heaviest component, but it would be placed in the secondary classification "debris/other" because the concrete may make recovery difficult.

   Items containing potentially hazardous waste:

   - These items should always be classified in the primary category "Potentially hazardous waste". For example a tin with paint residues or a used sealant tube. For the sake of consistency, this also includes empty items or containers.

   Note: Items or containers in primary WAP categories 1 to 5 and 8 are by definition free of potentially hazardous waste.

2. Where only some of the secondary WAP categories are used for a primary WAP category, a “mixed” category should be included to cover the other material that has not been sorted, eg. paper my be subdivided into “office paper”, “corrugated cardboard”, “paperboard” with “mixed paper” for the other secondary categories newspaper, printed material etc.

Sorting logistics, construction bin waste

The sorting trial of construction bins run at Pikes Point Refuse Transfer Station in 1997 provides an insight into what is involved in sorting construction bin waste:

- The bins were tipped out onto the concrete slab for sorting in an area sheltered from wind and rain.
- The bins were sorted by picking out the various materials and collecting them in a selection of large bottom opening metal bins ($1.5m^3$), pallets and 240 litre MGBs.
- This process left a residue of "sweepings" - a mixture of soil, rubble, sawdust and small pieces of other materials. The composition of these "sweepings" was visually assessed before they were shovelled into a bin for weighing.
- Platform scales of three tonnes capacity (1kg accuracy) were used to weigh the sorted materials.
- A forklift was available to lift the larger bins onto the scales and to remove the sorted material for disposal.
- Information about each construction bin processed was recorded on a data sheet. (Similar to the example in Appendix 1)
- A note was made of any potentially hazardous or unusual materials found in the bin.
- A comparison between the total weight of sorted materials and the net bin weight from the weighbridge showed the discrepancy was generally less than 5%.

It is also useful to record the nominal size of the bin, in m^3, along with an assessment of how full the bin is, as a percentage. This information can then be used to estimate the density of construction bin waste, and possibly bulking factors for the main materials.

The sorting trial ran for a total of 18 days with a team of four, a leading hand plus three sorters. This team carried out the sorting, weighing and recording of the waste, then its removal to the main transfer station disposal area.

The basic processing statistics for the trial were:

- 102 bins processed in 18 days, an average of 5.7 bins per day
- total weight processed 142 tonnes, an average of 7.9 tonnes per day
- total labour input 676 hours, averaging 6.6 hours per bin and 4.8 hours per tonne
- the maximum rates achieved in one day were: 9 bins and 14.4 tonnes - on different days.

There was no clear relationship between the daily processing rates and the number of bins, tonnage or average bin weights. The processing rates in the first week quickly reached the overall average, and then varied widely through the trial, from 3 to 9 bins per day. This suggests that the variability of the bin contents and the availability of bins to sort may have had more effect on the sorting rates than the quantity of material being sorted.

Assessing waste reduction potential

The steps involved in assessing waste reduction potential from waste audit results are:

1/ Identify ways of reducing the quantity of each type of waste material, using the waste reduction hierarchy, avoid / reduce / reuse / recycle, as a guide. Estimate the proportion of the waste, as a percentage, that can be reduced by each waste reduction method. Two estimates may be used to reflect what would be "easy" and what could be achieved "with effort".

Note: Take care to be realistic and make sure reductions do not exceed 100% for a particular material!

Several methods may apply to the same material, eg. timber waste may be reduced by: making sure offcuts are used where possible, reuse of boxing and collecting remaining offcuts for use in the manufacture of particle board.

2/ Create a table or spreadsheet - material categories and audit results down the side and headings for reduction methods, cost factors, estimated reductions and benefits across the top. Typically the calculations included for each material are:

- the weight reduction, ie. audit weight times the reduction %
- the weight reduction as a percentage of the total.

The overall weight reduction is the sum of the reductions for all the materials. Dividing this by the total weight gives an estimate of the potential reduction overall.

3/ The value of waste reductions can also be calculated from these estimates by:

- applying the costs factors used to calculate the cost of waste earlier, in particular savings in waste disposal charges
- allowing for the revenue or cost of recovering materials, eg. income from metal sold as scrap, the transport costs associated with alternative disposal methods.
- calculating the cost benefit from the reuse of materials.

Note: The validity of waste reduction estimates is dependent on the assumptions used to estimate the aggregated waste quantities used in the calculations, ie. the issues are the same as those discussed earlier in relation to extrapolating audit results.

4/ Priorities for implementing waste reduction initiatives may be set based on the materials:

- showing the greatest cost benefit

- offering the greatest reduction by weight
- making up the largest portion of the waste

From an initial list of priority materials, operational issues such as the availability of outlets for recovered materials, the ease of keeping them separate and the likelihood of success may also need to be taken into account when finalising a waste reduction programme.

Appendix 1 includes an assessment of waste reduction potential, based on data from the sorting trial of construction bin waste, as an example of this process.

Construction considerations

The hallmark of the construction process is change - change during the project and between projects. This presents a number of challenges when using and interpreting the results from audits of construction waste. The main problems are that:

- for most projects it will be difficult to obtain a representative sample of waste from a limited waste audit, ie. by only auditing a few bins.
- audit results from one project may not be applicable to future projects, ie where the scale of the project or the type of construction changes.

The "project" nature of most construction activities present further issues that need to be taken into account when developing waste reduction programmes.

Samples from a limited waste audit

The materials used in construction change as the project progresses, eg. from the concrete and reinforcing steel used in foundations to the timber and gib board used in framing and lining. As a result the composition of bin waste is likely to change as the project progresses. Depending on how long it takes to fill a bin, the contents will reflect waste materials arising from one or more stages of the construction, ie. a part of the project.

On a large project, the location of bins may affect the contents of bins even though they have been filled around the same time, eg. from different floors of a high rise.

These problems can be addressed several ways:

- By treating each waste audit as a "snapshot" of the construction process; thus it is important to record information that will allow the audit results to be related to the construction activities generating the waste, eg. details of the time over which the bin was filled and its location if the site has several bins. The stages of construction can then be identified from the construction program or site diary.

  These "snapshot" results can then be used to address the reduction of waste arising from the corresponding construction activities.

- By conducting a limited number of audits, with bins selected so as to build up a representative picture of the waste arising from all stages of the project. This is an appropriate method for dealing with larger projects where a small proportion of bins may be audited. The audited bins may be selected on a periodic basis, eg. every 10th bin, one bin a week, or by location, eg. all bins from the 3rd floor.

  In this case it is essential that an estimate of the total quantity of waste leaving the site is also obtained, typically from the waste contractor's invoices, so that the audit results can be extrapolated to provide estimates for the project as a whole.

- By conducting a complete audit of all the waste from a project, thus avoiding any problems associated with sampling the waste. While this would require a significant commitment of resources for all but the smallest projects, it may be a feasible approach where a representative project is selected, eg. one house for a group housing company.

Different types of project

The composition of waste may also vary from project to project due to different types of construction, eg. timber framing, structural steel, insitu concrete, and due to the scale of the project. Thus audit results should include some background information about the project:

- the type of construction; based on the main structural materials used, eg. timber framed, structural steel, concrete
- the stage of construction; eg. substructure, framing, lining, finishing
- the project type; residential or business and new building or renovations.
- the size of the project (floor area and construction cost)
- the construction period; start date, completion date, duration
- the main contractor, site manager

This information can be used to check for differences in the composition of the bin waste for these categories of project.

Until a pool of data from a variety of project is available, care should be taken when comparing audit results from different projects.

Waste reduction issues on construction “projects”

Most waste reduction case studies relate to factories, retailers or offices, where the same range of products or services are offered month after month. The construction site presents a very different environment:

- the workplace is continually changing, with large quantities of materials moving through confined and often limited spaces
- buildings are typically “one off” projects - ie. a new team, a new design and a new site for each project
- the roles and responsibilities for waste and waste reduction are distributed among designers, the main contractor and subcontractors.

There is a growing number of construction companies in New Zealand who are addressing these challenges and are making progress in reducing the waste arising from construction activities.

The REBRI project aims to provide a forum and focus for networking and for developing and sharing information and techniques that will assist the construction industry achieve improved performance through waste reduction.

Acknowledgments

The author wishes to acknowledge the feedback on the first draft of this guide provided by Peter Mittermuller, Resource Efficiency Unit, Auckland Regional Council, Roman Jaques, Building Technologist, BRANZ and by staff at Waste Not (Auckland).

Appendix 1

Contents:

Average Weights for Construction Bins

(Net weight of contents for $9m^3$ bins)

	Number of Bins	Avg Bin Wgt (Tonne)
Overall Average	102	1.39
By Stage of Construction		
Timber Framing	6	1.35
Lining	20	1.45
Finishing	24	1.38
By Type of Construction		
Light Timber Frame	45	1.48
Concrete Structure	14	1.42
By Type of Project		
Residential		
New buildings	13	1.86
Renovations	26	1.15
Non-residential		
New buildings	6	1.36
Renovations	13	1.67

The main factor affecting bin weights appears to be the Type of Project.

These results are based on a trial of sorting construction bin waste, conducted in 1997. The report on this project is available from the Auckland Regional Council.

Volume to Weight Conversion Factors for Waste Construction Materials

These volume to weight conversion factors[†] (also known as bulking factors) can be used to convert volume estimates (in cubic metres) of waste construction materials into weight estimates in kilograms. Thus they allow estimates of waste composition by weight (in kilograms or tonne) to be obtained from the results of visual assessments of waste quantities (in cubic metres) for construction waste.

The figures, derived from field measurements made in North America[‡] are very rough and the additional assumption has to be made that the conversion factors are similar for construction waste in New Zealand. Despite this, they are the best available data on the effective densities of materials in construction waste bin.

Material	Conversion Factor (kg/m^3)
Wood	178
Wood sheet	200
Cardboard	38
Plaster-board	238
Mixed/other	225
Metal	63
Paper & plastic	38
Concrete	900
Sweepings	208

An indication of the effect that the bulking factor has on volume estimates of material in construction bins can be obtained by comparing the density of solid steel - 7,800 kg per cubic metre, and the density of metal construction waste - 63 kg per cubic metre. The reason for this difference is due to most steel construction waste being items such as long-run roofing, wrapping straps and reinforcing mesh that have huge amounts of air around them when dumped into a bin, creating a very much larger volume than their weight would suggest.

[†] The information, including the table of conversion factors, was provided by Roman Jaques, Building Technologist, BRANZ.

[‡] Base information sourced from "Residential Construction Waste Management - A Builders Field Guide - How to save money and landfill waste", National Association of Home Builders (NAHB) Research Centre, Maryland, 1997.

Appendix 2

<u>Classification Guide for Construction Waste Audits</u>

Suggested classifications based on Waste Analysis Protocol

Alphabetical listing of common construction materials