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Financial evaluation of waste management methods: a case study

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FINANCIAL EVALUATION OF WASTE MANAGEMENT METHODS: A CASE STUDY

ABSTRACT

This paper investigates the relatively new field of waste management in the construction industry, and examines the success of the waste management system implemented by Barclay Mowlem Construction Pty Ltd on the Vantage Apartments project in Brisbane. The study incorporates the assessment of the current on-site waste management operations plan, a financial feasibility providing a comparison between traditional waste disposal methods, waste disposal methods as adopted on this site, and proposed environmental ideal waste management methods. Finally, a statistical analysis to determine waste quantities generated and the success of the current methods implemented.

A best comparison is made between traditional waste handling methods, the system used on the Vantage Apartments project and an idealised system of total waste management. Results indicated the total cost of waste handling and disposal for the Vantage Apartments project was approximately the same as for traditional methods. For the idealised system of total waste management, there was an increase of cost of 66% over the traditional method.

The success of waste separation on the Vantage Apartments project was not realised to its fullest potential. This result is partially attributable to difficult site conditions and the subcontractor's unfamiliarity with a Waste Management Scheme. It is anticipated that improvement in these

areas would require better control and planning of waste handling. Although it is obviously environmentally beneficial to increase efforts in waste separation and recycling it must be considered that costs do increase substantially should tighter on-site controls be implemented, and that if the recycling opportunities are not readily available, there is little potential for any substantial financial or environmental gains.

KEY WORDS: waste management, construction waste recycling, waste management plan, building waste, construction law, waste costs.

1. INTRODUCTION

It is estimated that 13-30% of all solid waste deposited in land-fills world-wide comprises construction and demolition waste (Bossink and Brouers, 1996) with a 1:2 ratio of construction to demolition waste (Bossink et al, 1996). In Holland, for example, this amounts to around 4.25 thousand million tonnes of construction waste each year. Insights into the causes of the generation of waste in construction projects are growing however (Bossink and Brouwers, 1996; Gavilan and Bernold, 1994) and waste management policies have been developed in Europe for example (Van Dessel and Vyncke, 1995). In response to increasing awareness of the environment, the Australian Government has established several strategies to implement ecologically sustainable development (ESD). One major arm of ESD is the National Waste Minimisation Strategy, which has set a target of a 50% reduction in waste, 15% of which is from building and demolition work, going to land-fill by the year 2000 based on 1991 standards.

This shift in social attitudes towards environmentally friendly values together with the possibility of future state and local government legislation or taxation on the lines of the UK Landfill Tax Trevorrow, 1996) suggests that strict guidelines for commercial ventures will soon be introduced. Therefore, it is becoming necessary for organisations to establish some form of environmental management system. Previous studies in this field suggest that high rates of success may be obtained by implementing waste management strategies in the construction industry. Other defined benefits include financial gains, through the sale of salvaged products or reduced disposal costs, and environmental benefits (Trevorrow, 1996; Alford, 1996; SKM, 1996; Heino,1994).

Budgeting and planning for waste handling and disposal on construction projects, however, has been minimal to date. Often this segment of the overall contract works is seen as contributing only to a minor portion of the total project cost and is unlikely to greatly affect the overall competitiveness of a tender price. Also, waste handling and disposal costs are subject to considerable variation and are difficult to determine accurately in advance. In addition, there are very little cost data available. Subsequently, to value this item, estimators are forced to use approximation methods only.

Several common methods of deriving costs include the use of a predetermined percentage (%) rate apportioned to the project value; a dollar rate per Gross Floor Area; or experience gained from previous projects. Advantages of estimating waste disposal costs accurately include a tighter budget which in turn will facilitate a more competitive tender price.

This paper describes an evaluation of the waste handling and disposal methods used on an actual construction project in south east Queensland by using financial and statistical means. With the

information thus derived, a comparison is made between the waste handling techniques used on a site with traditional waste handling and a hypothetically ideal waste handling and disposal system.

2. CASE STUDY: VANTAGE APARTMENTS PROJECT

2.1 The Project

The waste management methods employed by a major Australian construction company and their operation on one construction project in the Brisbane area of Queensland were studied. The project was 'Vantage Apartments' - a Brisbane inner city apartment project completed in October 1996. Access to the site did not present any problems for coordinating through traffic as the site was located at the end of the local traffic area. The construction works consisted of two (2) residential towers of five (5) stories each featuring high quality apartments, underground car parking and landscaped surrounds. Both towers were serviced by a permanent crane established centrally. Throughout the site were designated lay-down areas for the storage of goods, site accommodation and waste bins as required.

The project served the purpose of being a pilot project for the contractor in regards to waste management. It was intended to provide a comprehensive trial of waste management procedures and did so successfully. There were several features of note: no previous data or information was available to draw on; personnel were unaccustomed to waste management procedures; there were restrictions on labour availability and time; and there was no material hoist on-site limiting capacity of handling segregated waste containers. The contractor had already commissioned and

received a consultant report for a Waste Management Strategy for a recent brewery project and the principles noted in this report were also implemented on the case study project. These concerned: bin positioning, use and identification; the workers induction program; the provision of a list of local recyclers; and the collection of statistical information.

The contractor drafted a Waste Management Plan (WMP) clearly defining its policy, staff responsibilities and procedures to be adopted and designed to meet and exceed the company's current obligations under the Environmental Protection Act 1994. Although some guidance was provided to develop ways in which to avoid or minimise waste, no specific guidelines were established in work process optimisation, material planning, on-site training and methods of effective and efficient reporting of waste quantities.

The Project Manager correlated the trades represented on the program with the major waste streams, to establish which products presented an opportunity to recycle. Anticipated wastes suitable for recycling included concrete, masonry, timber, metals, plasterboard. Other waste not suitable for recycling and disposed of as general waste incurred normal disposal charges. Handling methods were considered crucial to the effective disposal of waste with the aim of maximising recycling to benefit the environment and reducing disposal costs.

2.2 The waste contractor

A specialist waste transportation firm was employed on this project with primary responsibilities included the provision of waste collection bins and labelling of the bins to suit the waste streams identified in the contractor's WMP.

Early negotiations with the specialist enabled the planning of suitable methods of disposal of various waste streams and allowed the setting of a fee scale depending on the items removed. The contractor's WMP stipulated that waste material could become the property of the waste removal contractor on collection from site, and that any rebates paid on recyclable products should be made to the account of the waste removal contractor.

The task of monitoring was delegated to the specialist waste handler and included data collection and the subsequent collation and analysis. The driver of the waste bin service truck was responsible for determining where the waste was to be delivered to and whether it was contaminated or not. If the waste was considered to be contaminated the site supervisor was informed and asked to co-sign the delivery docket to indicate agreement that it was contaminated and would be unsuitable for recycling.

At the point of pick up the driver recorded the date, bin size, waste product type and the place of disposal. This method of data collection produced only approximate results. There was concern about the accuracy of data available for this study because of the lack of awareness by drivers of the type of product to be collected and where it was to be disposed.

The waste analysis undertaken by the waste specialist for the contractor provided a month by month breakdown of wastes removed from site and information regarding the specific waste streams targeted for separation and recycling. Calculations were based on weights and provided monthly and cumulative totals and percentage ratios of the respective wastes.

3. ANALYSIS

To determine the success of the waste management strategy used for Vantage Apartments, it was necessary to examine handling and disposal costs and carry out a waste creation and separation analysis. Of course, this can only provide indicative figures as the waste management process is necessarily subject to variances through a variety of different influences that occur on construction sites, including project type and size, site layout, materials handling, management, labour, trade types and skill levels.

Two analyses were conducted: (1) the level of waste creation and separation at Vantage Apartments; and (2) a waste stream cost analysis of Vantage Apartments in comparison with both traditional and 'ideal' methods.

3.1 Waste creation and separation analysis

The objective of this analysis was to assess the waste segregation success realised on the Vantage Apartments project. The three major waste producing trades, with the greatest recycling potential were:

- Timber - derived from formwork trade,
- Plasterboard - derived from the ceiling and partition trade, and
- Masonry - derived from concrete, blocklaying and paving trades.

It was anticipated that the results would:

1. Indicate achievements on this project
2. Indicate the recycling potential of each waste stream
3. Act as a guide to further efforts required to improve on current accomplishments
4. Allow a comparison between actual achieved waste handling results versus anticipated.

This analysis was divided into two parts, those being a specific waste stream flow analysis of timber, plasterboard, and masonry, and a determination of the rates of success for each waste type.

Firstly, the waste stream flow analysis forecast waste quantities and their timing based on the construction program, which enabled a comparison to be made with actual waste removed from site. To achieve realistic projections, the construction program was examined to determine the current activities under way at any particular time. An approximate waste factor was allowed for higher wastage due to activity start up and the tradesmen's learning curve. The data used for actual waste quantities removed from site was derived from information given by the waste contractor.

Secondly, the total waste quantities were factored against estimated waste quantities derived by applying standard industry waste percentages to material quantities used on-site. This enabled the percentage success rate for the project waste management in the areas of timber, masonry and plasterboard separation to be assessed. As the weight data of bins given by waste contractor was inaccurate, an estimate was been produced considering percentage of trade waste produced, bin filling levels, material densities and waste bulking factors.

The above described techniques were applied to the plasterboard, timber and masonry waste streams, considered as contributing to the majority of the on-site waste. Other items such as metal, paper and general waste were not considered as there was insufficient accurate data available.

3.2 Waste stream cost analysis

A variety of handling techniques were considered for comparative purposes:

- *Traditional.* These incorporate disposing of all rubbish into general waste bins situated on site with nil consideration to separating any waste;

- *Current.* These are the methods employed on the Vantage Apartments Project and incorporate partial success in environmental waste handling methods;

- *Proposed.* These are seen as having very high levels of waste segregation and environmental awareness on the building site.

This analysis was also divided into two parts: a waste stream projection to approximate anticipated waste quantities; and a cost analysis to determine approximate overall costs.

3.2.1 Waste Stream Projection

The estimation of waste stream quantities was made by considering the main project activities on a time scale. Against this, the actual waste quantities removed from site were plotted and the waste streams for the three waste handling methods were derived using estimation for the traditional and proposed waste handling, and actual data for current handling methods implemented on the Vantage site.

It was anticipated that the results would enable the following:

1. Provide estimating and planning information to determine requirements on future projects.
2. Provide waste stream quantities for cost analysis.
3. Allow a cost analysis of traditional, current and proposed waste handling methods.

3.2.2 Cost Analysis

The cost analysis considered the complete project waste cycle to derive the costs incurred in implementing the three waste handling methods of traditional, current and proposed waste handling methods involved. The items incorporated into the analysis included the following:

- Handling on work deck,
- Supervision and labour to load into crane,
- Cranage and hoisting times,
- Waste transport and disposal costs

- Other miscellaneous costs.

Various quantities, costs and times were derived in consultation with Vantage Apartments project staff and management.

Critical to the analysis were the Waste Proportion Handling Requirements, which quantify the proportions of waste having to undergo various handling methods on site. As no accurate data was available in regards to this, estimates were made of these values.

Additional notes regarding assumptions made on the analysis were indicated at the base of each calculation sheet in the notes section. Finally, the summation of all the cost items in the Grand Total Waste Handling and Disposal Costs for each method were compared.

4. RESULTS

4.1 Waste creation and separation

Fig 1 provides an example of the calculations involved and these are summarised in Table 1.

The graphical representation of waste removed off site, shown in Figs 2a-c, indicates that waste segregation was irregular. This result could be attributed to either the stockpiling of waste on-site until quantities warranted removal, or inconsistent waste separation techniques. Of concern was the plasterboard result which had a disproportionately high waste factor at the start of the forecast waste creation period and then there was no further separated material, possibly indicating

inaccurate assessment of the waste stream by waste contractor's drivers, and poor waste handling of this material for a majority of the project. The graphs indicate the forecast waste flow of a particular material, facilitated planning of the correct recycling material bin for a particular type of waste. A waste flow analysis was actually carried out by the project manager on this project and his anticipated waste bin requirements determined at the start of the project are overlaid on the Figures.

Overall, using the estimated waste quantities determined on the Vantage Apartments project, plasterboard, timber and masonry contributed to approximately 19.5 percent of all the waste produced on this site and were considered to be major areas of recycling potential.

4.2 Waste stream costs

Fig 3 provides an example of the calculations involved. The volumetric proportions of waste quantities derived on-site and comparative costs using traditional, current and proposed methods are shown in Tables 2 and 3 respectively.

These results provide a clear indication that the disposal costs of waste properly segregated would be reduced. However, analysis of the complete process of waste handling on-site suggests an increase of $25,582 would be needed to implement a waste management plan fully, which represents a 66% increase in costs over traditional waste handling and disposal methods.

5. CONCLUSIONS

The success of waste separation on this project was not realised to its fullest potential. This was partially attributable to difficult site conditions and the subcontractor's unfamiliarity with a Waste Management Scheme. It is anticipated that improvement in these areas would require better control and planning of waste handling. Although it is obviously environmentally beneficial to increase efforts in waste separation and recycling it must be considered that costs do increase substantially should tighter on-site controls be implemented, and that if the recycling opportunities are not readily available, as was the case for plasterboard, that there is little potential for any substantial financial or environmental gains.

Often discussions of waste management speak only of the cost benefits associated directly with disposal costs of waste material. But, as is presented, additional handling due to carrying out waste separation fully would increase costs substantially and would have a bearing on tender competitiveness or project profit margins.

6. ACKNOWLEDGEMENTS

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CAPTIONS

Fig	Caption
1	*Example calculation of waste segregation success*
2a	*Plasterboard actual versus estimated waste flow*
2b	*Timber actual versus estimated waste flow*
2c	*Masonry actual versus estimated waste flow*
3	*Example calculation of handling and disposal analysis*

Table	Caption
1	*Recycling success and opprtunities*
2	*Waste stream quantities comparison (by volume)*
3	*Waste handling cost comparison*

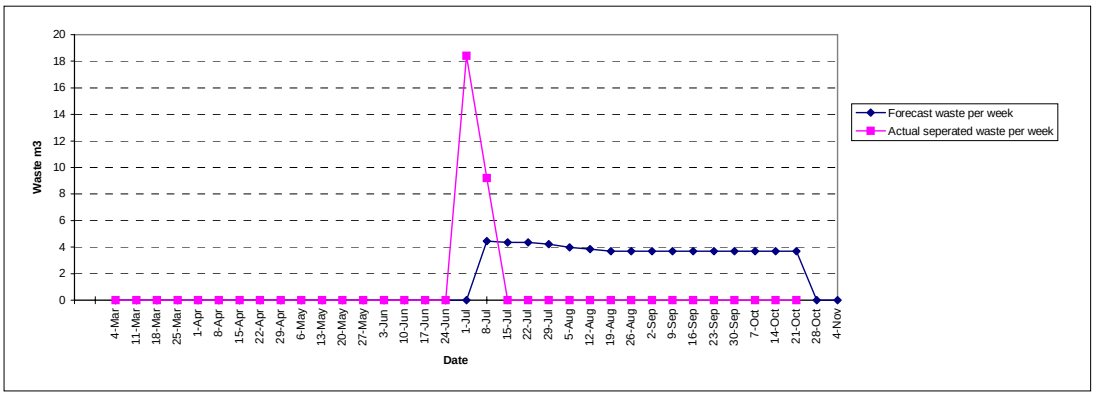

Figure 2a: Plasterboard actual versus estimated waste flow

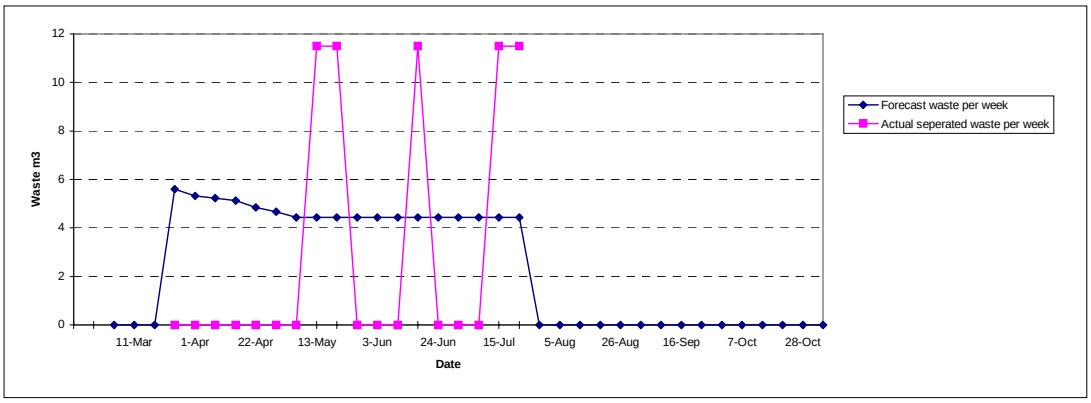

Figure 2b: Timber actual versus estimated waste flow

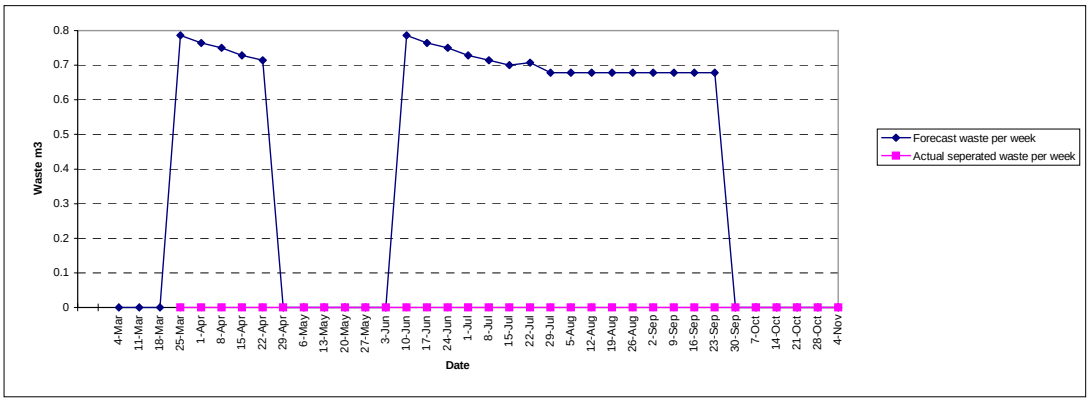

Figure 2c: Masonry actual versus estimated waste flow

Table 1 - Recycling Success And Opportunities

Waste Stream	Estimated waste Produced (Tonnes)	Estimated Waste Factors (%)	Actual Waste separated for Recycling (Tonnes)	Recycling Success (%)	Potential Recycling opportunity (11.5 m3 Bins)
Plasterboard	81.1	18 %	35.92	44 %	7 Bins
Timber	30.3	refer calcs.	16.56	55 %	7 Bins
Masonry	16.2	2 %	0	0 %	2 Bins
TOTAL	127.6	n/a	52.48	41 %	n/a

Note: This exculdes metal and paper waste, due to a lack of information, which also represent a recycling opportunity.

Table 2 - Waste Stream Quantities Comparison (by volume)

Waste Types	Traditional Methods (m3)	Current Methods Of Vantage Apartments (m3)	Proposed Methods (m3)
Potentially hazardous (contains plasterboard)	552	35	81 (*)
Hardfill waste	253	701	523 (*)
Masonry	0	0	23 (*)
Timber	0	58	92 (*)
Metal	0	0 (*)	18 (*)
Paper	0	11 (*)	68 (*)
Contaminated	21	21	21
TOTAL (m3)	**826**	**826**	**826**

(*) Denotes information not available and therefore estimated

Table 3 - Waste handling Cost Comparison

Waste Handling Method	Waste disposal and transport Costs	Total waste handling and disposal Cost	Project value Percentage Approximate total project value of $10,000,000
Traditional	$15,694	$ 38,809	0.388 %
Current	$14,149	$38,949	0.389 %
Proposed	$12,793	$64,391	0.644 %

Fig 1: Waste Segregation Success

PLASTERBOARD

Area & Type		Approx. Quantity (m2)	Waste % (*)	Waste m2	Waste Volume
10mm Gyprock to walls		18112.00	18%	3260.16	32.60
13mm Gyprock to walls		1274.00	18%	229.32	2.98
10mm Gyprock to ceilings		6845.00	18%	1232.10	12.32
TOTAL VOLUME OF WASTE (Compact)				m3	**47.90**

Bulking Factor of waste in bin	1.30	
Plasterboard Density	1.69	t/m3
TOTAL VOLUME OF WASTE (In Bin Loose)	62	m3
TOTAL MASS OF PLASTERBOARD	**81.1**	**Tonne**

Estimate of weight per bin (due to Collex data being incorrect as previously described)

Bin fill level	80%	
Bin Capacity	11.50	m3
MASS OF PLASTERBOARD PER BIN	**11.97**	**Tonne**
Collex estimate	**4.00**	**Tonne**

Total Tonnage retrieved

No. of Bins	3.00	No.
Combined Weight	**35.92**	**Tonne**

SEGGREGATION SUCCESS

Total waste created	81.05	Tonne
Total waste separated	35.92	Tonne

Seperation / Recycling Success — 44%

Potential Recycling Opportunity — 7 Bins

Notes:

It should be kept in mind that variations in bulking factors estimated and in material types and sizes seperated will make a

substantial difference to the overall success rate
(*) Waste factors adopted were derived through discussion with site personnel

Fig 3: Traditional Method - Handling and Disposal Analysis

Handling / Sweeping on deck into piles

Factors		Resulting Cost per m3
No. of labourers	1.00	$6.25
Labour Rate ($/hr)	25.00	
Time (min.)	15.00	
Waste Volume (m3)	1.00	

Supervision and labour to load into crane bins

Factors		Resulting Cost per m3
No. of labourers	2.00	$10.00
Labour Rate ($/hr)	25.00	
No. of dogmen	2.00	
Dogmen rate ($/hr)	35.00	
Time (min.)	10.00	
Waste Volume (m3)	2.00	

Crane / Hoist Time

Factors	$/hr	Resulting Cost per m3
Crane Cost $/hr ($5000 / week at 40 hrs / week)	125.00	$17.71
	minutes	
Bin Hookup	2.00	
Lifting To Deck (avarage)	1.50	
Bin holding time at deck level	10.00	
Bin lowering to ground	1.50	
Unloading time	2.00	
Crane Cycles per clean up operation per floor (No.)	1.00	
Waste Volume (m3)	2.00	

Waste Transport and disposal costs

	Quantity (m3)	Bin Volume m3	No. of Bins	Cost per bin	Total Cost per waste straem
Potentially hazzardous waste (Contains plasterboard)	552.00	11.50	48	230.00	11040.00

Hardfill waste	253.00	11.50	22	202.00	4444.00	
Masonry	0.00	11.50	0	168.00	0.00	
Timber	0.00	11.50	0	180.00	0.00	
Metal	0.00	5.50	0	0.00	0.00	
Paper	0.00	3.00	0	0.00	0.00	
Contaminated / General	21.00	1.50	14	15.00	210.00	
Total Waste Transport / Disposal Costs	826.00	m3			**$15,694**	

Miscellaneous Items

Project Duration (weeks) 36.00

	$/hr	hr/week	total project hours	Cost
Management / administration	40.00	0.00	0.00	0.00
Site Supervision	30.00	0.10	3.60	108.00
Education / Induction	20.00	0.00	0.00	0.00
Overheads (item)				0.00
TOTAL COST				**$108**

Total Waste handling cost

		Waste proportion handling requirement (%)				
	Waste Quantities	Handling / Sweeping on deck into piles	Supervision and labour to load into crane bins	Crane / Hoist Time	Waste Transport and disposal costs	Total Cost per item
Potentially hazzardous waste (Contains plasterboard)	552.00	100%	80%	80%	11040.00	26726.00
Hardfill waste	253.00	100%	80%	80%	4444.00	11633.42
Masonry	0.00	0%	0%	0%	0.00	0.00
Timber	0.00	0%	0%	0%	0.00	0.00
Metal	0.00	0%	0%	0%	0.00	0.00
Paper	0.00	0%	0%	0%	0.00	0.00
Contaminated / General	21.00	100%	0%	0%	210.00	341.25
Miscellaneous Items	n/a	n/a	n/a	n/a	n/a	108.00
Grand Total Waste Handling and Disposal Costs						**$38,809**

Notes: