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Assessment of e-waste options for Metropolitan Perth, Western Australia

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IN CONFIDENCE

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Glossary of Terms and Acronyms

AIIA	The Australian Information Industry Association, representing 450 information and communication technology (ICT) industry members.
Basel Convention	The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal is a global agreement which aims to minimize the generation of hazardous wastes in terms of quantity and hazardousness, to dispose of them as close to the source of generation as possible and to reduce the movement of hazardous wastes
Bioaccumulation	The process by which substances accumulate in the tissues of living organisms at a greater rate to that by which they are lost. Can be used to refer to accumulation up the food chain (into the higher predators) or the tenancy of a substance to accumulate in certain organs or areas in the body (e.g. liver or fatty deposits)
Commingled recycling	Common recyclables, mostly packaging; such as glass, plastics, aluminium, steel, liquid paper board (milk cartons). Commingled recycling may include paper but often, and particularly in offices, paper and cardboard are collected separately.
Computer peripherals	Equipment associated with home computers such as keyboards, mice, screens and printers.
CRT	Cathode Ray Tube – glass 'tube' found in glass screen TVs and older style monitors
DFD	Design for Disassembly. Often considered a desired outcome of EPR; manufacturers of a product are mindful of the need to design for ease of recycling.
e-waste	For the purposes of this report, this term refers to electronic waste including computers, laptops, computer peripherals (e.g. printers, faxes etc.). Depending on context this term can be applied to all electrical goods (anything with a plug or rechargeable dry cell battery power source)
EPHC	Environment Protection and Heritage Council, with the objective of ensuring the protection of environment and heritage of Australia and New Zealand
EPR	Extended Producer Responsibility - a strategy designed to promote the integration of environmental costs associated with products and to encourage manufacturers to take greater responsibility for environmental outcomes of their products
General Waste	Material that is intended for disposal to landfill (or in some States, incineration), normally what remains after the recyclables have been collected separately.
Kerbside Collection	Regular collection of waste and/or recyclables from the front of each house or dwelling in a local government area
LCD	Liquid Crystal Display - Commonly used in digital watches, camcorder view-screens and laptop computer screens, LCD panels are light-weight and low-power display devices

MGB	Mobile Garbage Bin – A wheeled bin with a lid often used for kerbside collection of waste or recyclables. (Often called a 'wheelie bin').
OECD	The Organisation for Economic Co-operation and Development (OECD) brings together countries that are committed to democracy and the free market economy to foster prosperity and fight poverty through economic growth and financial stability
PC	Personal computer – generally refers to standard desktop 'tower' computers (as opposed to supercomputers used for large scale processing applications)
PCB	Poly Chlorinated Biphenyl – persistent organic compound that was often used in high voltage transformers and other electrical devices until being discovered to have toxic properties.
PCB	Printed Circuit Board - thin board, usually fibreglass, on which computer components are mounted. So called because the connections between the components are printed onto the board
Recyclable	Material that can be collected separately from the general waste and sent for recycling. The precise definition will vary, depending upon location (i.e. systems exist for the recycling of some materials in some areas and not in others).
Recycling	Where a material or product undergoes a form of processing to produce a feedstock suitable for the manufacture of new products.
Re-use	The transfer of a product to another user, with no major dismantling or processing required. The term "reuse" can also be applied in circumstances where an otherwise disposable item is replaced by a more durable item hence avoiding the creation of waste (e.g. using a ceramic coffee mug in place of disposable cups).
Transfer Station	Location where waste and recyclables are collected and stored temporarily before transport to final destination. Transfer stations may be at a landfill premises or at an independent site. Some sorting of recyclables may occur at these sites.
Vergeside Collection	Sometimes known as 'hard waste' or 'bulky waste' collection. The collection of bulky items of discarded 'junk' (e.g. furniture, TVs, barbeques etc.) from households on a regular, but infrequent basis (generally about 4 times per year).
WEEE	Waste Electronic and Electrical Equipment (definition commonly used by European Union).

Executive Summary

The EMRC and SMRC commissioned Encycle Consulting to undertake a desktop review of e-waste collections occurring elsewhere and to recommend an appropriate model for recovering e-waste (as defined above) from householders and small businesses in metropolitan Perth.

This Report captures the existing situation for e-waste disposal and recycling elsewhere and in Perth and considers various collection models potentially available for e-waste in Perth, identifying the benefits and drawbacks of each system. Recommendations are provided as to the most suitable collection model and the factors that might be considered in implementation of an e-waste collection system in Perth. A summary of the key points relating to each system is provided in Table 10, Section 5.

There are no readily available data on the proportion of all e-waste that is made up of household 'big ticket' electronic items such as televisions, computers and stereos. From a bottom-up calculation however, this is likely to be between **2,000 tonnes and 4,000 tonnes per annum** for municipal e-waste in Perth Metropolitan area (Table 3).

It is not clear exactly how much of the e-waste generated in Perth is recycled, but it is likely that a very small percentage of *municipal* e-waste is recycled with much being stockpiled, re-used or sent to landfill. (To determine the amount of total e-waste recycling in Western Australia that is municipal electronic waste would require a more detailed research project to be conducted).

Motivations for householders to recycle stem from the desire to 'do the right thing' and a sense of environmental responsibility combined with the fact that major electronic items have a perceived value and it would not seem appropriate to simply put such goods in the kerbside wheelie bin. However, it is unlikely that many residents would be willing to pay a fee to dispose of their electronic waste.

The key benefits of recycling e-waste include reduced health and safety risks from not placing the material in landfill and also the ability to re-use and remanufacture electronic goods, thus making computers and other technologies available to a wider cross-section of the community. Electronic goods contain an array of toxic metals (including lead, cadmium and mercury). It is unclear how safe these products are in even the best practice landfills in Western Australia.

The main systems (used around the world) for collecting e-waste for recycling include: central drop-off locations, vergeside collection and various one-off e-waste collection days. Permanent drop-off locations have been demonstrated to be a popular and cost-effective means of collecting e-waste for recycling across many of the other areas studied and are recommended as the most workable, cost-effective and risk-averse e-waste recycling option for Perth. One-off e-waste collection days could work well as a subsidiary means of collection for more remote communities.

The amount of e-waste generated in Australia is growing 2-5 times more quickly than the growth rate of municipal waste (reported growth rates vary greatly). Intuitively, from looking at increased sales of electronic items in the last ten years or so, it is obvious that while good prediction figures are not available e-waste is becoming a significant problem in the waste stream and will need to be dealt with sooner or later.

1 Introduction

This assessment of e-waste collection options for Perth local government has been carried out for EMRC (Eastern Metropolitan Regional Council) and SMRC (Southern Metropolitan Regional Council).

The project to look at the e-waste issue in Perth and to identify appropriate collection models was split into two key areas:

- Tasks 1 and 2 involved gathering data and information to quantify the magnitude of the e-waste issue in Perth (Task 1) and also the barriers, householder motivations and benefits of collecting e-waste from residents (Task 2).

- Task 3 draws together the information from Tasks 1 and 2 and assesses different collection models that might be applicable to the Perth context.

This Final Report provides the background information and data described in Tasks 1 & 2, then goes on to assess the possible collection models and provide recommendations as to potentially successful scenarios for collecting municipal e-waste in Perth. This Report includes facets of e-waste collection models such as data gathering and in particular, suggestions for the collection of Brand data that may assist State Government with the development of an Extended Producer Responsibility (EPR) Scheme under the *Waste Avoidance and Resource Recovery* (WARR) Act (2007).

It should be noted that data relating to e-waste in Western Australia are sparse and inconsistently measured. Data limitations relevant to this project are discussed in more detail in Appendix 2.

In parallel to this project, the EMRC & SMRC are investigating the various recycling options for the electronic waste once it is collected. Project managers from EMRC and SMRC have already held discussions with a number of the WA recyclers (for reuse & recycling) and are looking to summarise details on:

- Recycling costs
- Scope of materials accepted for recycling
- Dismantling options
- Packaging requirements
- Recycling pathways
- Environmental impact assessments
- Economic impact assessments

Consequently, these aspects of e-waste recycling are not covered in this report.

1.1 Project Aim and Methodology

For the purpose of this project, e-waste is defined as major electronic household appliances, including computers, laptops, computer peripherals and media equipment such as DVD players and stereos. The focus of the report is on e-waste generated from householders and small-medium enterprises (that would use municipal waste services).

The Scope of this project is to undertake a desktop study to:

- Estimate the amount and types of electrical and electronic equipment available for recycling in Perth metropolitan area.
- Summarise the motivations (or barriers) for disposing of electronic waste.
- Summarise the economic and environmental benefits or impacts to local government of providing e-waste collection service/s (particular reference to greenhouse gas emissions).
- Summarise the social benefits or impacts to residents of providing e-waste collection service/s.
- Ascertain the distances the majority of people are willing to travel to correctly dispose/recycle electronic waste.

Further, to investigate and recommend:

- 'Types' of e-waste to be collected (will also be guided by recycling options).
- The most economically viable, socially acceptable and environmentally sensitive e-waste collection model/s that could be implemented in the Perth metropolitan area by the Regional Councils.

EMRC and SMRC are seeking to investigate the models for implementation of an e-waste collection system across Perth. Appendix 5 provides an overview of the Regional Councils in Perth; local governments, populations and areas.

The approach to achieving the aims of this project was to review existing literature on the generation of e-waste and undertake analysis to convert the data into figures that are relevant for municipal sources of electronic waste in Perth. Sources of data often related to national figures and generally describe all sources of e-waste including major commercial, education and other institutional waste streams.

Information on the motivations, barriers and benefits of e-waste recycling was collated from relevant reports from studies undertaken both in Australia and overseas. A substantial amount of information was provided by the project manager at EMRC, and substantial additional research was undertaken to complement this information.

Summary tables are provided in this report using a combination of information sources. The meta-data for these tables are provided in the Appendices to this report.

1.2 Background: The e-waste issue, health and environmental considerations

For the purposes of this project report, e-waste is defined as common domestic electronic equipment including televisions, personal computers (PCs), laptops, home entertainment equipment, printers, faxes and other computer peripherals. In this context, e-waste does not include electrical equipment such as kitchen appliances, power tools or small battery powered toys or gadgets, although in some situations, these goods are included (e.g. the European Union WEEE Directive).

Electronic goods such as TVs and computers are now seen as a necessity to everyday life in the developed world. As availability and affordability of electronic goods increases, the trend over the last 20 years has been an increase in ownership of electronic products and of a broader variety is paralleled by decreasing life expectancy of these products and greater 'disposability'. Most Australians will not be surprised to learn that on average, houses in WA have more than 2 television sets (IPSOS, 2005) or that average life expectancy of computers and laptops is steadily falling.

1.2.1 Health concerns

Electronic goods are a cause for concern and the health impacts of the various trace metals, plastics, fire retardants and composites are well documented (EIA 2000, EEB 2001, EPA 2000, OECD 2001, SVTC 2001). Table 1 provides a summary of the key elements and materials that a standard personal computer might be made of (Meinhardt, 2001).

Table 1: Average Material Composition of Personal Computers

Material	% Weight	Material	% Weight
Silica	24.88	**Bismuth**	0.0063
Plastics	22.99	**Chromium**	0.0063
Iron	20.47	**Mercury**	0.0022
Aluminium	14.17	**Germanium**	0.0016
Copper	6.93	**Gold**	0.0016
Lead	6.30	**Indium**	0.0016
Zinc	2.20	**Ruthenium**	0.0016
Tin	1.01	**Selenium**	0.0016
Nickel	0.85	**Arsenic**	0.0013
Barium	0.03	**Gallium**	0.0013
Manganese	0.03	**Palladium**	0.0003
Silver	0.02	**Europium**	0.0002
Beryllium	0.02	**Niobium**	0.0002
Cobalt	0.02	**Vanadium**	0.0002
Tantalum	0.02	**Yttrium**	0.0002
Titanium	0.02	**Platinum**	Trace
Antimony	0.01	**Rhodium**	Trace
Cadmium	0.01	**Terbium**	Trace

From Table 1, a selection of some of the materials of concern with regard to environmental and health impacts include:

- **Brominated flame retardants** (found in plastic casings): these are potentially soluble in landfill leachate and can bioaccumulate (see glossary for definition of bioaccumulation). Little medical research although dusts have been associated with effects on liver, renal system and neural development (Darnerud, 2003).[1]
- **Cadmium (Cd):** known to accumulate in the human kidney. At high doses (the order of only a milligram of Cd), will produce health effects on the respiratory system and has been associated with bone disease
- **Chromium VI (Cr^{6+}):** easily absorbed and can produce various toxic effects including severe allergic reactions, asthmatic bronchitis and potential damage to deoxyribonucleic acid (DNA) in cells.
- **Lead (Pb):** bioaccumulative and has a long list of both acute and chronic toxic effects including damage to nervous system, brain function, digestive system and renal system.
- **Mercury (Hg):** bioaccumulative and persistent; can cause damage to the brain, endocrine system and kidneys.

It should be noted that the health impacts listed here are just a short selection of the many potential dangers of the toxins found in electronic products. The toxic substances found in electronic products are numerous in both their variety and in their impacts upon human beings and the health of living systems.

Photo (above): e-waste awaiting collection (not well contained)

[1] The industries that manufacture plastic casings are currently researching alternatives to brominated flame retardants. Much of the stimulus for better design and less hazardous material use has been driven by the EU's Directive on Waste from Electrical and Electronic Equipment (WEEE) and the EU's Directive on Restriction of Hazardous Substances (RoHS).

1.2.2 Landfilling and toxic trace metals

The circuitry, wiring, casings and screens of electronic waste contain many trace metals which are potentially harmful as discussed very briefly in the Section 1.2.1.

There are currently very few scientific studies that look at the mobility of trace metals in landfill and there is also a lack of consensus from the few existing pieces of research. Studies have shown that metals are generally mobilised early on in the degradation phase (Kjeldsen *et al.* 2002). However, the phenomenon of placing significant quantities of electronic waste into landfill is only recent and the science has yet to be proven.

The chemical behaviour of trace metals in the general environment is already well understood. The likelihood of trace metals from electronic goods being mobilised into solution is related to: **acidity, presence of soluble organic compounds and the absence of oxygen** (Ettler *et al*, 2006). In landfill, as food and garden waste breaks down, a liquid known as 'leachate' is formed. The composition of leachate varies according to the conditions and the composition of the fill. However, leachate is commonly characterised by being acidic, rich is organic compounds and low in oxygen (Kjeldsen *et al.* 2002). The conditions found in landfill leachate are thus likely to be excellent at mobilising the rare metals found in electronic products. If leachate escapes from a landfill, these toxic metals could contaminate groundwater, water courses and land. Some of the more readily mobile trace metals, such as cadmium and mercury are also some of the more potent human toxins.

In Western Australia, Class II landfills are able to receive electronic waste but do not have an impermeable liner (as is present in Class III and Class IV landfills) (see DoE, 1996 for definitions of landfill class). The lack of a landfill liner is of great concern as this makes it more highly likely that leachate will leak into the surrounding environment.

1.2.3 Alternative Waste Treatment and e-waste

Western Australian waste management systems rely to a significant and increasing extent, upon Alternative Waste Treatment (AWT), particularly in the Perth area. AWT in Perth makes use of various technologies in order to divert organic material from landfill by separating this material from the general waste bin and biologically processing it into an organic soil conditioning product. In this way, AWT has a positive impact upon greenhouse gas emissions from landfill.

The use of mixed municipal waste as the feedstock to the AWT process means that metals commonly found in electronic equipment may be present in the organic material after treatment (Papadimitriou *et al*, 2008). Although the AWT process does involve a pre-processing separation stage to remove non-organic material prior to biological processing, this sorting cannot be guaranteed to be complete, particularly if e-waste products are broken up.

1.2.4 Avoidance of improper disposal or processing

Recycling of e-waste can be contentious as many developed countries have believed that they were 'doing the right thing' only to find that their e-waste was being exported to developing countries where people were dismantling units under poor health and safety conditions and exposing themselves to serious health risks. Perth Metropolitan Regional Councils are making clear and concerted efforts to ensure that e-waste collected in Perth will be sent to reputable

companies who are either Australia-based or licensed under the Basal Convention and able to dismantle the units and recover the materials according to high standards of health and safety.

1.2.5 Resource Depletion

Many of the metallic elements used in the manufacture of electronic products are what are known to most chemists as 'rare earth elements'. The metals used in electronic goods have very specific properties and there are currently no synthetic alternatives. It is difficult to predict the changes in technology or the demand for some of these elements in the medium to long term but at the current usage rates, these elements are disappearing globally at an alarming rate (to landfill/incineration). Recent research shown in Table 2 has estimated the number of years left of various metals assuming current rates of consumption (i.e. these figures assume conservative rates of growth in demand for new technology).

Table 2: Number of years left at current global consumption rates (not taking changes in demand for technology into account) (New Scientist, May 2007)

Element	Common uses	Years remaining	Proportion of consumption met by recycling
Antimony	Flame retardant plastics	30	0%
Copper	Electrical connections, wire	61	31%
Indium	LCD screens	13	0%
Lead	Cathode ray tubes, batteries	42	72%
Nickel	Batteries	90	35%
Silver	Various	29	16%
Zinc	Batteries, galvanised steel	46	26%

1.3 Waste Management Policy in Western Australia

The Western Australian State Government has committed to a policy of "Towards Zero Waste". This means that activities to promote recycling and waste minimisation are encouraged. New legislation was enacted in 2007: the *Waste Avoidance and Resource Recovery Act* 2007 (WARR Act), which provides State Government with greater powers to require reporting and enforce regulations that will drive the reduction of waste to landfill. The State Government of WA and indeed most international governments adopt a hierarchy of preferred waste management options which are: Avoid, Reduce, Reuse, Recycle, Dispose.

1.3.1 Extended Producer Responsibility

Extended Producer Responsibility (EPR) is a policy approach under which producers accept significant responsibility - financial and/or physical - for the treatment or disposal of post-consumer products. Assigning such responsibility could provide incentives to prevent wastes at the source, promote product design for the environment and support the achievement of public recycling and materials management goals (OECD, 2001).

The WARR Act (2007) provides the State Government with greater powers to put EPR Schemes in place in Western Australia. Under the WARR Act, manufacturers or importers of a product may put in place a voluntary 'Product Stewardship Scheme' whereby the industry self-regulates (with the approval of the CEO of the Department of Environment and Conservation) to achieve similar goals to that which might be expected from a formal EPR scheme in terms of material recovery. Some manufacturers have already implemented voluntary Producer Responsibility recycling schemes in Australia, most notably, Dell and Hewlett Packard.

Currently, there is no formal, industry-wide scheme for the recovery of e-waste (as electronic and/or electrical waste) between State Government and the relevant industries. The Western Australian Local Government Association (WALGA) has recently released a position paper on the priority products for Product Stewardship or EPR schemes. In this paper, WALGA names e-waste as the number one priority for an EPR scheme. WALGA prioritised products in the waste stream in terms of:

- Significant environmental or social impacts
- Significant costs for waste/recycling processors
- Unrealised potential for recycling
- Likelihood of illegal disposal
- Community concern
- The extent to which the producer is well-placed to reduce the impacts of their products

The information for this work was gathered from the Problematic Waste Survey of Local Governments, undertaken by WALGA in June 2008. The responses to the survey overwhelmingly identified e-waste as being problematic, but with potential for a suitable scheme to be set in place (citing the 'ByteBack' scheme in Victoria).

Much research has been carried out to look at the most appropriate recycling schemes for electronic goods in Australia (Nolan ITU, 2004; Environment Australia *et al*. 2001). The Australian Information Industry Association (AIIA) has previously attempted to develop a national voluntary industry producer responsibility scheme but this model didn't get through the Environmental Protection Heritage Council (EPHC) process as there was a feeling that the scheme proposed by the AIIA lacked substance and did not take full responsibility for recovery of waste (WME Magazine, 2 December 2005).

Far greater success has since been realised by the work of the AIIA and Sustainability Victoria in the development and running of the 'Byteback' pilot program to recover computer waste from residents and small businesses in Victoria (http://bytebackaustralia.com.au). The program has been trialled for 18 months and the AIIA are now keen to roll-out similar programs in other states.

2 Review of current literature relating to e-waste disposal and recycling

This section presents information gathered from a review of existing literature on e-waste generation, disposal options, life expectancy and potential collection systems.

2.1 Quantity and type of e-waste generated in Perth Metropolitan area

There is not an extensive amount of information about e-waste (specifically electronic waste) in Western Australia. Of the reports available, many deal with total e-waste volumes, that is, including all business, government, educational and private sector e-waste. Often, different definitions are used for e-waste and this can include "*anything with a plug*". Measurement of e-waste generation is complicated by the prevalence of informal re-use through friends, charitable organisations or more formally via the second hand IT market.

2.1.1 Re-use of electronic waste

The amount of e-waste likely to be discarded or fall into dis-use within a certain time frame can be calculated with some certainty, however the passing of material between people and organisations is notoriously difficult to quantify, therefore this report does not attempt to place any hard figures on re-use of electronic waste from householders in the Perth area. The ability to understand informal sales/donations through friends, local papers, charity shop donations with any degree of accuracy is highly unlikely.

Re-use is often a legitimate disposal route for householders and one that should generally be encouraged as the accessibility of computer equipment for all sectors of society can be argued to be a positive outcome, even if the environmental benefits are difficult to justify (second hand computers are unlikely to displace the purchase of new machine to any great extent) (OECD, 2001).

Computers and other e-waste may be shipped to a developing country for potential reuse, where there may be immediate worker health and environmental concerns if the computers are not ready for immediate reuse. Reuse of a personal computer in any country does not solve any environmental concerns regarding its ultimate fate but only defers the ultimate disposal or material recovery. A developing country without appropriate infrastructure for safe and environmentally responsible material reprocessing raises serious concerns and may not necessarily be a legitimate reuse option (OECD, 2001).

2.1.2 Recycling of electronic waste

A formal e-waste recycling industry in Australia is still under-developed. Whilst e-waste recycling businesses do exist and have become more prevalent, the industry is still young and often reliant on potentially ephemeral overseas markets. The electronics recycling industry does not have good industry standards that can be relied upon across the market and the level of credibility that a recycler might have varies widely. This variation in standards for processing of equipment can relate to the methods used, health and safety issues both within Australia and also once the material leaves the country is a potential reputational risk for the e-waste recycling industry as a whole. Certainly there are some businesses that operate to excellent standards of health, safety

and environmental integrity in Australia, but the risks to the industry can be tarnished by a few dealers who do not operate according to the same principles.

There are technical recycling challenges that face the recycling industry, including:

- Dealing with rapidly growing rates of waste production as electronic products become increasingly affordable and perceptions of disposability change
- Changing material composition of the products purchased and discarded as new technologies emerge (e.g. the move from cathode ray tube (CRT) TVs and monitors to LCD and plasma screens). Establishing infrastructure and finding markets for one waste material (e.g. CRT glass) over relatively short and discrete timeframes presents a greater challenge than for other recycling streams.

Over the past ten years in Western Australia, household ownership of computers (and associated peripherals such as printers) has more than doubled from 300,000 households having access to computers at home in 1998 to 613,000 households in 2006/07 (ABS: 8146.0, 2007). Over the same period, there were a total of about 700,000 households in 1998 to nearly 800,000 households in 2006/07; so the proportion of households with computers rose from about 43% to over 75%.

Undertaking meta-analysis of the information currently available (detailed in Appendix 1), Table 3 shows the likely **available** e-waste in Perth for 2006/07. The figures presented here are calculations for electronic waste (computers, home media players and computer peripherals) generated from private householders for the Perth area.

Table 3: Likely available (potential) e-waste generated from households in Perth metropolitan area* *(note that this does not take into account the amount already stockpiled by householders)*

Equipment	Units per year	Tonnes per year
Computer boxes and laptops	12,000 - 60,000	235 - 1,100
Printers, Monitors and Peripherals	120,000 – 150,000	650 – 1,000
Home media equipment (Videos, DVDs and stereos)	90,000 – 150,000	260 – 450
Televisions	40,000 - 50,000	800 - 1,000
Estimated total tonnage Perth municipal electronic waste per annum		~2,000 – ~4,000
Approximate TOTAL *ALL* e-waste generation - Perth (not sum of column)		(7,000 – 9,000)†

*See Appendix 1 for details of meta-analysis
†This figure is for total e-waste generation, not just electronic equipment – see Appendix 1

It is estimated that approximately **30,000 tonnes of new electronic equipment** entered WA in 2005 (computers, peripherals, videos, stereos and televisions) (data adapted from Hyder, 2006). 10-15% of this quantity for Perth households would be approximately **2,000 – 4,000 tonnes per year.**

2.1.3 Stockpiling

It is likely that a significant proportion of the quantity of e-waste that is discarded or no longer used in 2006/07 (Table 3) would actually be placed into storage (stockpiled) or sent for re-use and not actually be presented for disposal or recycling. Note that Table 3 specifically refers to e-waste that is likely to be sent for recycling or disposal from householders in Perth and so does not include the quantity that would be stockpiled. The quantity of e-waste placed into storage depends largely upon the type of equipment; stockpiling of e-waste is mostly related to size and perceived value by the householder (IPSOS, 2005). Expensive and large items such as computer boxes are more likely to be stockpiled or re-used than printers or video players.

The number of units in storage is estimated to have grown by nearly seven times over the past ten years (Hyder, 2006) so it is likely that the stockpile will continue to grow over the coming years. Placing a figure on the actual amount of e-waste currently stockpiled appears to be a matter for debate. The Australian Information Industry Association (AIIA) place a figure of between 5.2 million units and 23.2 million units in storage (across all sectors in Australia) which would roughly equate to between **2,000 and 9,500 tonnes of computers from municipal sources in Western Australia** (see Appendix 1 for calculations). Whereas Sustainability Victoria conducted a national survey as part of the 'ByteBack' scheme and found that just 640,000 obsolete computers were being stored by householders which equates to just **1,500 tonnes in WA homes** (75% of which would be in Perth).

The tendency for householders to stockpile electronic goods will have contradictory impacts upon the quantity of e-waste presented for recycling. Firstly, stockpiling will mean that recently disused equipment will not enter the waste stream directly, so decreasing the amount of material provided for disposal or recycling. Conversely however, a greater amount of material may be produced for disposal or recycling than expected from the stockpiled material that has collected over many years.

2.2 Motivations and Barriers for householders to dispose of e-waste appropriately

Householders tend to associate electronic products with having a residual value and hence feel reluctant to simply throw unwanted products in the bin (IPSOS, 2005). Certainly, compositional analyses of general waste collection identify relatively little electronic waste in the kerbside bin. Whether the use of kerbside bins for disposal changes over time as equipment shrinks in size and perceived value is another matter. A significant amount of e-waste is re-used on both formal and informal routes. It may be that the decreasing size of electronic products will actually improve recovery as it becomes easier to deposit the material at central collection points (e.g. postage is sometimes used for small products such as mobile phones).

There is a general expectation that waste generated by residents will be collected from the home unless they are thought to be unusually large or difficult waste streams in which case it is reasonable to transport material to a local transfer station (Hyder Consulting, 2008).

Washington State Department of Ecology conducted a survey of their residents' response to their e-waste collection system in 2002. The key findings were:

- Above all, respondents agreed that any program must be free or at minimal cost to residents.
- Locations and hours must be convenient. Respondents did not define convenience in terms of miles travelled, but most said either a "central" location or multiple sites scattered throughout the area would work.
- Respondents seemed to think that either periodic collection events or a variety of drop-off sites would work. If drop-off sites were chosen, respondents suggested adding them to existing recycling centres, household hazardous waste facilities, or transfer stations and landfills. Some respondents who favoured drop-off sites noted that the ability to visit the sites at any time is a benefit.
- Some respondents suggested expanding existing programs such as household hazardous waste facilities or collection events.
- Many respondents emphasised the need for extensive education and advertising of any program.
- Some respondents indicated interest in seeing product-stewardship programs such as deposits at the time of purchase or buy-back programs.
- As mentioned above, many respondents indicated that any program must be free or at minimal cost.
- Residents often feel a 'social need' to participate in recycling. An e-waste collection service would provide people with an opportunity to make an environmentally positive gesture
- Often electronic goods are perceived to retain a residual value, even if they are obsolete or no longer working; this value often makes residents reluctant to simply 'throw them away'

2.3 Distance householders are likely to travel to deposit e-waste at a recycling area

2.3.1 Washington, USA

Very few significant studies have been carried out on the distance that residents are willing to travel to recycle, and even less so with particular reference to e-waste. A survey in Washington, USA (Washington State Department of Ecology, 2002) received a high response from residents who said that they "*did not define convenience in terms of miles travelled, but most said either a "central" location or multiple sites scattered throughout the area would work*."

This might indicate that the best approach would be to look at providing facilities at locations where residents would travel to anyway such as existing transfer stations or possibly at popular retailer sites.

2.3.2 Southern Metropolitan Regional Council, Perth, WA

A study was carried out in 1999 by Southern Metropolitan Regional Council to look at behaviours around responsible disposal of household hazardous waste (Market Equity, 1999). It is likely that people's attitudes to disposal of household hazardous waste may not be exactly the same as those for e-waste, the report does provide an insight into the distances that people are willing to travel to dispose of products correctly. The survey results showed that the majority of people (75%) were unwilling to travel more than 20 minutes to dispose of household hazardous waste. It is likely that some behaviours and attitudes for e-waste may be a little different to household hazardous waste due to the increased perceived value of the products. However, this report provides a good indication that an average householder will tend to avoid travelling much more than 20 minutes to dispose of a product or material. The report identified that key barriers to appropriate disposal of household hazardous waste were the distance that a householder might be required to travel and the level of inconvenience of the location. Convenient locations for disposal were identified in the Market Equity report as: shopping centres, service stations and council buildings.

2.3.3 Byteback survey, Victoria

A short survey was conducted of only 37 people in regions where the Byteback scheme operates in Victoria (Byteback, 2008), whilst a very small sample size, 30 of the 37 respondents indicated that they would be prepared to travel up to 30 minutes to drop off a computer (Byteback is specifically computers/peripherals but not other e-waste items such as televisions).

Reponses to the Byteback small survey included 4 out of 37 people who would *not* be prepared to travel in order to drop off their own e-waste and one respondent who did not have a car.

2.3.4 Belfast, Northern Ireland

The study carried out in Belfast, Northern Ireland collected information about where people had travelled from to dispose of their e-waste as part of the trial program. However, 94% of those questioned, had travelled from within the standard catchment area for the transfer station which is less than 5 kilometres radius.

Belfast is a highly sectarian city with people unlikely to travel through different areas or long distances and is a densely populated city, making this study of little relevance to Perth.

The New South Wales Recycle IT! pilot project found that the distance participants were willing to travel to a collection site differed depending on the collection method. For the permanent sites, participants travelled on average 10 km, compared to an average of 5 km for the one-day events. This was despite the fact that the one-day events were promoted heavily to a far larger geographic area.

2.4 Barriers to Householder recycling participation

There has been little or no research into householder's barriers to e-waste recycling specifically. Householders in Australia are generally concerned about waste and engaged with the concept of 'wanting to recycle'. The vast majority of Australian households recycle (98%) and reuse waste (87%) (ABS, 2006). Recycling is seen as something that householders are able to participate in as a way to have a positive impact upon the environment (or at least a less negative one). Recycling is frequently cited as the behaviour that householders commonly perform in order to 'help the environment'. Embraced behaviours appear to need to:

- Be affordable
- Be easily accessible
- Be linked easily to environmental benefit.

(Hyder Consulting, 2008)

It should be noted that community support is generally strongest for issues that have attained high profile in media and in education programs or are obviously a problem in people's day to day lives (e.g. plastic bags). The low level of engagement with a landfill and lack of appreciation for the toxicity issues association with electronic waste are likely to be a key barrier to the success of an e-waste recycling program and should be tackled in the communication and promotion of the system; emphasising the benefits of recycling e-waste.

There is a danger that the less 'accessible' take-back systems for electronic goods reduces the participation rate (as discussed below). However, if there is no obvious environmental benefit (such as leaving products on the vergeside for collection, then this will not necessarily obtain the required participation or engage those that need to 'feel good' about active participation in recycling.

An extensive survey of West Australians in 2007 revealed these key reasons that respondents cited for not recycling:

- Lack of Knowledge – not knowing how, where or why to recycle
- Apathy – a lack of interest in where a product ends up
- Laziness – recycling will involve a greater effort than simply putting something in the bin
- Too hard – the high effort required to recycle is prohibitive
- Why bother (response to common misconception about recyclables going to landfill)

(Synovate, 2007)

Additional standard reasons for not recycling include:

- Perceptions of normality – if no other residents nearby are recycling, there is little motivation to attempt to recycle. This contrasts with the situation when recycling is considered 'normal behaviour' and it would be strange not to
- Lack of understanding about how and what items to recycle

- Lack of knowledge about why recycling is important
- Cynicism about the benefits or the likelihood of material actually being recycled

2.5 Barriers to e-waste recycling for the recycling industry

In general, the recycling of the more common materials and products becomes more viable as the reliability of feedstock (in quantity and homogeneity) increases and the markets for the recycled material stabilises. Arguably, the metals produced from e-waste recycling already have a well-established market; however there are other factors that present barriers to e-waste recycling which are listed here:

- Cost: High cost of labour for dismantling components
- Cost: A lack of market and low value for plastics with flame retardant additives
- Technical barrier: difficulty in recycling plastic materials due to additives and diversity of polymers
- Logistics barrier: difficulty in efficient aggregation of significant volumes of products
- Logistics barrier: lack of access to reprocessing facilities for many components within Australia
- Policy barrier: lack of a product stewardship commitment from the information technology industry sector
- Behaviour barrier: Perception that products still have a value at end of life leading to stockpiling and reluctance to pay for recycling
- Dismantling barrier: as the range of products and manufacturers increases, the ability to dismantle products easily is diminished (dismantling is the key factor affecting the return of recyclable parts)

(From Hyder 2006, Meinhardt, 2001, DEC, 2008 *pers. comm*.)

2.6 Disposal Routes for e-waste

A common problem with e-waste is that at the end of useful life to the owner (even if a unit is still in working order) residents do not know what to do with the product. Very commonly, computers and other e-waste has a high perceived value, which means that people are generally unlikely to dispose of them in the bin but will store the product or pass on to another user. As previously mentioned, the reuse of e-goods may be either to a friend or relative or through charity stores or other second-hand trading mechanisms.

Table 4 is taken from a survey conducted by IPSOS in 2005 which asked respondents from across Australia about their electronic items in the household and the way that they were disposed of. The figures in Table 4 show that many people seek alternative solutions to simply throwing e-

waste in the bin; including re-use and re-sale. The results in Table 4 do not distinguish between the people who take e-waste to a local council collection point for disposal or for recycling, but the results do indicate a level of willingness to use this route for disposal.

Residents demonstrate a reluctance to throw away e-waste, often opting for re-use. This demonstration of the desire to see the computers recycled and re-used is an important consideration when choosing a method for collection of e-waste; residents must feel that they have 'done the right thing' and contributed to an environmentally beneficial outcome. For instance, kerbside collections may remove this opportunity for active participation.

Table 4: Main Disposal Methods for four e-waste categories (from IPSOS, 2005)

Disposal Method, top mentions only (Ranked by Mentions)	TVs (%)	PC Monitors (%)	Box Units (%)	Portables (small goods) (%)
Gave away to family/friends	26	31	35	8
Council pick-up collection service	26	22	19	10
Took to local tip/council depot	17	10	12	12
Sold privately to another person	5	5	6	3
Gave to repair shop / PC mechanic / second hand dealer	4	2	2	1
Took to charity shops/collection bins	3	7	8	5
Used as trade in	2	3	4	0
Wheelie bin/normal garbage bin	1	2	3	51
BASE: TOTAL ITEMS DISPOSED OF	4.35M	2.03M	1.66M	2.20M

Table 4 is taken directly from the Ipsos report. Not all responses are shown, hence the figures do not total 100%. The last row in Table 4 shows the total number of each type of item disposed of in Australia. The figure of 'total items disposed of' is provided to show the relative impact of each product type, i.e. whilst 35% of respondents said that they had given computer box units away to family/friends compared to only 26 % respondents for televisions, over 2 and a half times more televisions are disposed of (4.35 million compared to 1.66 million), thus showing that televisions will have a far greater relative impact upon the waste stream. Note, it is not clear from the report how the 'number of items disposed of' is calculated, it is possible that this is estimated for all Australia from knowing the proportion of total population that make up the sample of interviewees.

2.7 Benefits to Local Government of implementing e-waste recycling

The benefits to local government from implementing e-waste recycling have been captured under four areas: environmental/health and safety, direct local government benefits, future

proofing benefits, and policy benefits. Financial implications for e-waste recycling collections are discussed in more detail in Section 3.5.

2.7.1 Environmental/ Health and Safety benefits of e-waste recycling

Electronic waste represents a significant investment of energy and resources. As such, to recycle these products will preserve resources and save energy. Climate change impacts of recycling e-waste cannot be specifically calculated but are discussed in detail in Appendix 3.

The main environmental and health and safety benefits of e-waste recycling are listed here:

- Resource recovery: valuable metals in electronic goods such as lead, aluminium, nickel, mercury, cadmium and lithium can be recovered and recycled, representing a sensible use of finite resources and nearly always using less energy than extracting 'new' metals (Sustainability Victoria, 2008)
- Climate Change impacts: Computer recycling is generally considered to be preferential to disposal to landfill on a life cycle basis (Byung-Chul Choi *et al*. 2005) (refer Appendix 3)
- Risk limitation to residents: e-waste left on vergeside for collection can present a health and safety risk to residents, pets and wildlife as it is accessible to vandals (e.g. smashed glass, sharp metal pieces, toxic elements in components)
- Risk limitation to local environment: as above, vandalism of e-waste at the vergeside can leave potentially toxic components on verge, in road and can enter stormwater run-off
- Risk limitation to illegal/unsafe e-waste recycling: local government has the opportunity to investigate and audit the processes used to dismantle, transport and recycle their e-waste. By providing a service, local government is able to minimise the amount of material being sold to dealers who will send the material to developing countries (often illegally) for dumping or to be recycled using dangerous techniques
- Risk limitation to groundwater: potential leakage of elements from landfills into the groundwater from poorly lined landfills accepting municipal waste
- Airborne particles in the atmosphere are a danger to site workers on landfills and to residents (e.g. dust from smashed circuit boards or flame retardant casings)

2.7.2 Direct benefits for local government and their residents

The benefits to local governments and residents of an e-waste recycling system are also covered in the following two sections: future proofing benefits and policy benefits. Some of the direct beneficial impacts of an e-waste recycling service to local government and residents are:

- The cost of sending waste to landfill is expected to rise significantly over the next few years (and will continue to do so). Space for new landfills is scarce in the Perth area and the event of emissions trading in 2010 will place an additional cost impost upon Perth landfills

- A further opportunity to engage with residents about recycling, potentially increasing trips to drop off points for other recyclable materials and increasing householder recycling participation generally
- A collection scheme will provide an opportunity to publicise local charity collections for reuse of computers and peripherals. Increased reuse of electronic equipment is likely to be a benefit through improved access to computing for all sectors of the community
- Further developing the positive and pro-active image of the local government to residents and businesses with respect to responsible waste management (to avoid e-waste recycling may actually cause concern among residents)
- Perth-wide, a coordinated program would be simpler for householders to understand and engage with – no conflicting messages
- Coordinated marketing efforts can be employed across Perth and provide local government with the ability to use mass media, saving significant education and communication costs
- Providing a response to householder desire to dispose of products appropriately and an opportunity for householders to participate in recycling and feel good about 'doing the right thing'
- Long term benefit from the potential reduction in the need to manage e-waste-causing hazardous liquid emissions from local government owned landfills
- Local government will have the ability to collect data on the amount, type and brand of e-waste recycled in the Perth area. This will be exceedingly useful in furthering product stewardship and extended producer responsibility negotiations

2.7.3 Local Government future-proofing benefits

Disposal of e-waste is expected to double in five years (between 2006 and 2011) (Hyder Consulting, 2006). The benefits of introducing an e-waste recycling scheme to local government will include the ability to be ready for future changes in the waste stream. The e-waste stream is set to increase in quantity and complexity. It would be advantageous to have collection infrastructure in place that can be developed and adapted as needed.

Once infrastructure is in place, the system could expand to all electrical and electronic products to reduce vergeside collections and the loss of valuable metals and resources to general waste. Putting infrastructure in place may provide the opportunity for electronics company sponsorship.

2.7.4 Local government policy benefits to e-waste recycling

From a strategic viewpoint, the recycling of e-waste has several benefits to local government, these are listed here:

- Coordinated collection of e-waste will enable data collection that can be used to inform the establishment of extended producer responsibility (EPR) for electronic goods

- Transparency and Accountability – Local government will take responsibility for providing an auditable recycling process thus allowing householders to know where the material is going and to ensure that it is not being needlessly and potentially dangerously shipped to developing countries
- Reduced risk of material being sent disposed of illegally or recycled without adequate health and safety precautions (as per the Basel Convention)
- It is possible that future policy changes will introduce bans on e-waste to landfill or to make greater requirements for e-waste recycling

2.8 Potential Risks Associated with e-waste recycling systems

When considering commencing a recycling scheme, there will be associated risks that need to be considered.

The US EPA (United States Environmental Protection Agency) has set down a simple set of guidelines for 'Responsible Recycling Practices' which can be accessed on the EPA website: www.epa.gov/epawaste/conserve/materials/ecycling/r2practices.htm

These guidelines focus upon the risks associated with the actual reprocessing of materials and could be a good source of information when assessing the recipient recyclers for the program.

The US EPA information can also provide good background and act as a prompt to some of the key general concerns surrounding e-waste collection.

Some of the general risks that need to be considered by local and regional government regarding collection of e-waste are listed below. A separate section that discusses the risks for vergeside collections is provided separately as there are some specific risks associated with this method that do not apply to other collection mechanisms.

General risks associated with e-waste collection at drop-off location and at storage depots:

- At the outset of the scheme the substantial amount of e-waste currently stockpiled in homes across Perth will over-burden the new system
- If the scheme is not well supported by residents and Government it may become an economic burden on local government
- Other economic risks may include any investment in infrastructure or staff that becomes unnecessary in the future
- An injury occurs to staff or householders at a collection point
- That the scheme works extremely well and this is used by commercial stakeholders as a strategy for avoiding any producer responsibility scheme
- Increased break-ins at drop off location
- Concerns about 'pickers' or theft of material from site
- Increased potential for drop off location to attract illegal dumping of e-waste (or any other waste) (out of hours) if a direct charge is levied

Risks associated with vergeside (household bulky waste) collections:

- Local government staff are at risk of cuts or lifting injuries from moving e-waste (the Victorian Government has moved away from vergeside collections for health and safety reasons)
- Vandalism causes potentially toxic materials to be left on vergesides – either on grassed areas, in road or down stormwater drains
- Broken CRT glass causes injury to people or animals in the area
- Products left out for collection act as a signal to potential burglars as to the purchase of new products
- Products left out for collection are taken by 'scavengers' and there is no way to trace that they have been disposed of properly
- Personal data left on computers can be accessed if the machines are not removed and the hard drives wiped securely
- The quality of e-waste products is severely degraded when left outside, reducing the reuse potential and the material value of items

Photo (above): broken e-waste left in the open

2.9 Mechanisms for recycling of electronic products elsewhere

Table 5 provides an overview of some of the main e-waste recycling schemes operating around the world. In locations where formal, legislated extended producer responsibility systems exist,

there is generally a network of drop-off locations at local government transfer stations and retail outlets.

Despite the value of some of the metals in e-waste, all of the systems listed, even the well-established programs, appear to involve net operational costs. These costs can be covered by some form of levy where a legislated EPR system is in place. Where manufacturers are voluntarily involved in the program (such as in the Victorian Byteback program) some of the costs of reprocessing (often for their specific items) is covered.

Table 5: Systems used elsewhere in Australia and Internationally

Location	Law/ voluntary	Start Date	Products covered	Operational details
Victoria, Australia (Byte Back)	Voluntary partnership – government and industry pilot	Trial: 2006 - 2008	Computers and accessories	▪ Partnership between Sustainability Victoria (state Government) and some of main manufacturers through AIIA ▪ Funding provided for drop off sites, staff, equipment, transport to recyclers and recycling costs http://bytebackaustralia.com.au
NSW, Australia Recycle IT! (ended)	Voluntary partnership – government and industry pilot	Trial: 2002 - 2003	Computers and all peripherals (printers etc.)	▪ Partnership between Resource NSW(state Government) and some main manufacturers through AIIA ▪ Funding provided for drop off sites, staff, equipment, *transport to recyclers and recycling costs* *www.aiia.com.au* / *www.productstewardship.asn.au*
Australia	No formal scheme yet	-	-	▪ ad hoc collection days organised by local government or private organisations
New Zealand	No scheme but Waste Minimisation (Solids) Act	2008	Electronic waste	▪ Have EPR powers under new legislation but no formal, national scheme yet ▪ www.mfe.govt.nz/laws/waste-minimisation.html
California USA (CIWMB e-recycling)	e-waste Recycling Act	2003	Computers/ TVs and electronic	▪ e-waste recycling fee collected at point of sale which pays for drop off locations and recycling fees ▪ Recovery payments made to 'qualified' recycling companies ▪ Purchasing criteria for state government agency electronic products ▪ e-recycling website established to provide relevant information ▪ www.ciwmb.ca.gov/Electronics
British Columbia Canada	EPR legislation	2007	Computers, peripherals and televisions	▪ e-waste recycling fee levied at point of sale ▪ Recovery payments made to qualified recycling companies ▪ Drop off points at retail sites, charities etc. ▪ www.rcbc.bc.ca

Location	Law/ voluntary	Start Date	Products covered	Operational details
Japan	Law for recycling of specified home appliances	2001	Electronic equipment and white goods (up to 80% of e-waste)	▪ Recycling charge levied at point of sale and also subsidy received from manufacturers ▪ 380 collection points around the country feed 46 recycling facilities ▪ www.env.go.jp/en/recycle
EU member states (27 countries/ states)	EPR – law under the EU WEEE Directive	2003	All e-waste ('anything with a plug')	▪ Equipment producers must join compliance scheme which collectively funds recovery ▪ Fee collected either at point of sale or from manufacturer on entry to market ▪ Drop off sites as per each national programme, often retailers and local government sites ▪ Equipment distributors must provide information on safe disposal of item ▪ Equipment users must demonstrate appropriate disposal ▪ Targets set for 65% recycling/re-use of computers and 'consumer equipment' http://ec.europa.eu/environment/waste/weee/index_en.htm

3 Collection Models

This section discusses the factors to consider when deciding upon the collection model that is most appropriate for Perth Metropolitan area. The range of collection models used elsewhere for municipal e-waste are presented and the methods for collecting data and dealing with the e-waste are discussed. Table 9 at the end of Section 3 provides a summary of the e-waste collection model options.

3.1 Considerations for design of e-waste collection systems

Before deciding upon an e-waste collection system, it is important to understand what the key desired outcomes of a system are, what the boundaries are and where the responsibilities lie. Questions that need to be considered include:

- What are the motivations for implementing a program?
- What types of waste do you want to collect?
- Will there be limits on the quantities of waste to collect?
- Who will be eligible to participate?
- Will there be a fee for participation? – Issue of consistency – charging for some items and not for others is likely to result in increased illegal dumping. Also charges are levied by the recyclers – should this be passed on directly and will significantly more products be recycled if not?

- Which agency should take the lead?
- Are there others that can be encouraged to take the lead?
- Are there beneficial partnership opportunities? (e.g. with re-use charity/organisation?)
- Is there a model your community is already familiar with?
- Does this model offer a convenient program or should other types of programs be considered?

(CIWMB, 2004)

Some of the questions raised above are addressed further in this section and some recommendations are made. However, a full consideration of these questions by the lead agencies would be valuable, prior to embarking upon a collection system.

3.2 Motivations for implementing an e-waste collection program

For the scenario of collecting e-waste from residential Perth, the key drivers for embarking upon a city-wide collection system include:

a. Concerns about toxic metals entering landfills (particularly Class II, unlined landfills)

b. Responding to community requests for e-waste collection and recycling

c. Conservation of resources

There are obviously other benefits that are considered to make the implementation of an e-waste collection system worthwhile (discussed in Section 2.7). The major motivating factors listed here will provide focus for the decisions that need to be made about system design.

a. Concerns about potentially toxic metals entering landfills

The health and environmental impacts of some of the elements found in electronic waste are discussed in Section 1.2.1. Of all electronic and electrical products in the residential waste stream, the greatest concentrations of toxic elements is generally found in more technologically advanced electronic items, such as computers, televisions (CRT and LCD screens) and media equipment (e.g. stereos). Electrical goods such as kitchen white goods are generally less toxic in composition.

If toxicity is considered to be a key driver, then consideration of collection systems for other items, such as mobile phones and small, personal electronic products such as those that include nickel-cadmium (NiCad) batteries (e.g. some cameras, personal music players) might be included in the service.

In Western Australia, e-waste may be deposited in Class II landfills which are licensed to receive municipal waste but are generally not required to be lined. There is a higher likelihood that leakage from Class II sites may occur than from Class III or Class IV (lined) sites. There are no guarantees, however, that lined landfill sites will not leak. It is leakage of potentially toxic metals

and other element, dissolved in leachate generated from the decay of organic material that is a concern for the contamination of groundwater and land adjacent to the site.

b. Responding to community requests for e-waste collection and recycling

Community perception of the e-waste issue in Western Australia is not understood in great detail. It is likely that the desire to see e-waste collection operating is related to a general feeling that these goods have a high residual value and are too bulky to dispose of easily than any detailed understanding of environmental or health impacts.

For community engagement to be a key driver for an e-waste collection program, it is important that the system is simple and accessible. A system that successfully meets the community desire to recycle, should allow residents the opportunity to feel that the maximum value of the goods is retained through the process. This may mean that vergeside collection is less likely to meet the community engagement criteria. There does not appear to be a high value in the resources collected from vergesides and the message that material collected from vergesides is actually recycled is very difficult to reinforce. It is also important that the community are well briefed on the benefits of e-waste recycling and upon what is likely to happen to their waste goods.

c. Conservation of resources

In general, all electronic products contain valuable, non-renewable resources (aluminium, copper, steel, common plastics etc.) that make it environmentally preferable to recycle these goods than to landfill them. Recycling of most metals have not only the benefit of resource conservation, but will also have a significant energy saving (and greenhouse gas saving) associated with the displacement of mining, refining and smelting of raw materials.

Ultimately, the ideal situation would be for all electrical and electronic products to be recycled. However, a complete recycling system would be excessively onerous to roll-out immediately. As discussed in Section 1.2.5, some of the metals found in electronic items, particularly computers are rare and becoming increasingly scarce. Focussing upon collection of products which contain these dwindling resources is a good means for starting and establishing an environmentally beneficial e-waste collection program.

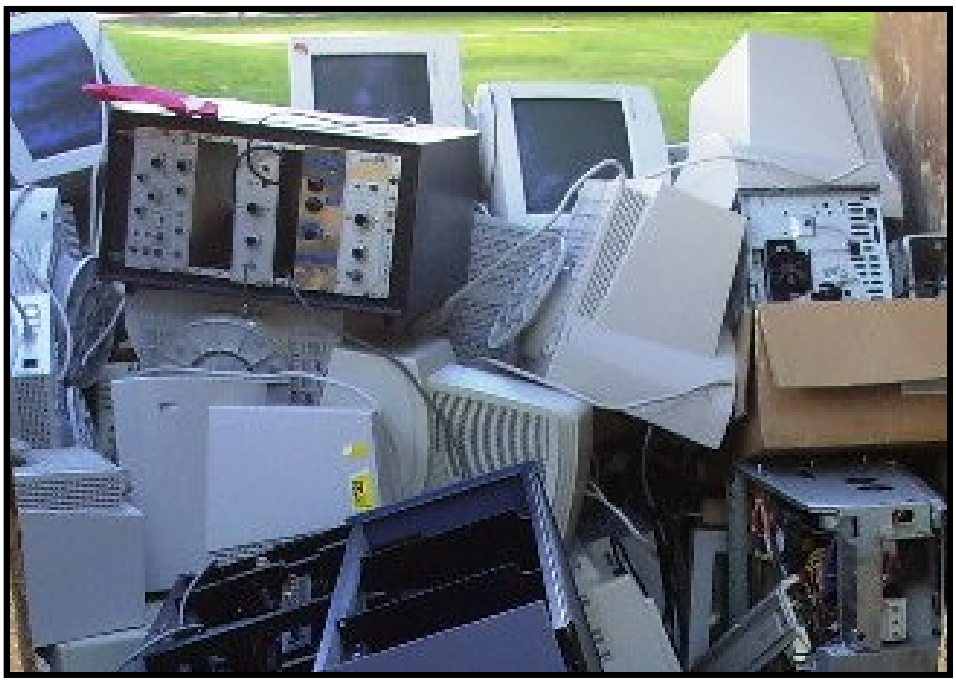

Photo (above): mixture of e-waste in a skip awaiting collection

3.3 Collection Model options

A collection system should be accessible to the majority of residents, simple to understand, effective at obtaining the materials in a suitably intact form, avoid undue risk to staff or residents, minimise operating costs and optimise recovery.

The key standard options used in other Australian states and overseas for e-waste collection systems include:

- Vergeside collection
- Permanent drop-off locations (e.g. at transfer stations, specific locations and retailer sites)
- Regular temporary drop-off locations (i.e. special e-waste days)
- Collection service from home or small business

In Australia, there have been two main pilot programs run for the collection of e-waste. In New South Wales in 2003/04 the **Recycle IT!** program trialled three different collection models in Western Sydney. These models were: permanent sites (located at waste management centres and retail outlets), one-day events (at Council Works Depots) and special events with limited access (at schools and corporate facilities). In Victoria, the **Byteback** program has been running for the past 18 months, collecting only computers and computer peripherals through a network of drop-off sites for Victorian residents and small businesses at both local government and retail

locations. Both Recycle IT! and Byteback have been run as a partnership between government (Resource NSW/ Sustainability Victoria as appropriate) and the IT manufacturing industry coordinated via the AIIA.

3.3.1 Vergeside collection

Collecting material from directly outside resident's homes is a useful way to obtain good participation. The other benefit of this system is that the infrastructure for the collection is largely in place already. If a 'special' vergeside e-waste collection were established, then specific vehicle use and staff time would be required. If no 'special' vergeside e-waste collection is established, then separating the e-waste from other material would be onerous and difficult.

On the downside, the material collected from verges has low 'perceived' value and participants would not feel the reassurance that material was being recycled. Residents currently often think that vergeside collection would generally end up as waste to landfill.

Risks associated with vergeside collections are high. Health and safety risks may be associated with leaving products with broken glass or sharp metal edges in the street and with the need for local government staff to pick up and carry large/ heavy objects. Environmental risks are related to broken pieces of goods being left on the grass verges or washed into stormwater drains. Security risks may be connected with personal data held on computers (such as banking details and passwords) and also to the opportunities for burglary on homes that have obviously recently purchased new products.

Leaving products on the verge for collection will possibly result in materials getting damaged by the weather. Degrading the materials (e.g. due to rust) will devalue the product. Vergeside collections are labour and vehicle intensive. Essentially, the local government will be taking on board the effort for transporting all material. The process of loading the products and transporting them may, depending upon the vehicle and procedures used result in some breakage of material.

Responsibility for capturing data regarding quantities and brands of products collected can be passed on to the recyclers in most cases. However, vergeside collection makes it harder to collect data for cross-checking or audit purposes.

Photo (above) e-waste on a Perth vergeside awaiting collection

3.3.2 Permanent drop-off locations

Once established, permanent drop-off sites are relatively straightforward to run. Permanent staff at the site are able to manage the material as it arrives and will be well trained in collection, loading for transport, data gathering and communication with the public about the destination of the material.

Permanent drop-off sites could be run either through existing local government transfer stations or at central retail sites (e.g. as with Officeworks stores in Victoria through the Byteback program; and with Bunnings and Dick Smiths stores in the New South Wales 'Recycle IT!' program). Site selection for collection points should take convenience and participant behaviour into consideration.

There are several benefits of utilising existing transfer stations or drop-off recycling points. There will be existing staff and infrastructure available, residents already understand that these sites exist and are used to taking material to them for recycling/disposal and there is a likelihood of capturing e-waste from residents that do not know about the program but are simply taking e-waste to the site for disposal.

The Recycle IT! program in New South Wales found that permanent sites were the most effective means of capturing material of the 3 different methods trialled (described above in Section 3.3,). The effectiveness of permanent sites was linked to the ability to capitalise on existing behaviour

such as including e-waste drop-off as part of a shopping trip or removal of several bulky waste items to a transfer station.

Communication with the local community about permanent e-waste drop-off points is simpler than for temporary points as the messages about what to do and where to go will remain consistent. The experience of attending the site will also be consistent for the residents and will reinforce the 'comfort' factor with the way the system operates.

3.3.3 Regular temporary drop-off locations (e-waste days)

e-waste collection days can often be a popular way of collecting material, particularly from more remote locations where residents may not have easy access to transfer stations or other collection points. The Recycle IT! pilot project in New South Wales found that one-day events had relatively low participation (despite extensive promotion) and that participants would only come from the adjacent areas to the collection sites. The situation in Western Australia has tended to be different (relatively good participation rates) but this may be due to a lack of other formal mechanism for e-waste recycling.

'Special event' e-waste recycling days can be held that work with a local school, organisation or company and restrict attendance only to employees/pupils. The Recycle IT! pilot project found that this option has an extremely high participation rate, even though this was from a small and homogenous target audience.

One-off e-waste collection days tend to be a very labour intensive process. Locations need to be determined, staff engaged (or transferred from other roles) for the day and trained, systems need to be established, collection points set up and loading of the material arranged. At the end of the day the material and all equipment will generally need to be removed from the site immediately, particularly if it is on a public space.

3.3.4 Collection service from home or small business

Western Australian Regional Government are keen to ensure that recycling services for e-waste are accessible to all of the community. Most e-waste recycling systems rely upon residents using a car to access the drop-off locations. Whilst car ownership in Perth is high, it is not 100% and some residents may struggle to deposit e-waste at a drop-off location.

Very few Local Governments internationally operate pick-up services for e-waste and none were identified in Australia. There are a couple of pick-up services for e-waste which run commercially, but will only collect for a substantial number of units (normally in the region of about 20 computers) or will charge a fee for the service.

If the staff and infrastructure are in place that will allow Local Governments to offer an *ad hoc* pick-up service to residents, then costs may be kept to a minimum. Some difficulties may arise in determining who should be allowed access to such a service, since a high take-up rate would be exceedingly costly. In this instance, the Local Government would be unlikely to widely advertise the existence of such a service, but perhaps offer this service via other community services that would target residents who would genuinely need the service.

An e-waste pick up service could perhaps be combined with removal of other waste and recyclables (e.g. household hazardous waste) or other services for less mobile residents.

Home pick-up services are unlikely to form a significant part of an e-waste service and may not require launching at the outset of an e-waste collection program for Perth.

3.4 Opportunities for re-use such as partnerships with charity organisations

Whilst re-use of electronic products is unlikely to have a significant environmental benefit compared to recycling (discussed in Section 4.2.3), the potential societal benefits available mean that re-use of working computers and other equipment are a good justification for partnering with organisations that will repair and/or redistribute these products (OECD, 2001).

Optimising the opportunity for electronic goods to be re-used will work best if partnerships with local charities or other organisations based in the Perth area are created. Some government organisations are tending to move away from schemes that ship equipment for re-use overseas to developing countries. Once electronic goods leave Australia, it is difficult to track where they have gone or exactly how they are being used. Many developing country destinations will not have adequate means of disposing of e-waste once their useful life is ended which may mean that we are simply displacing the problem to a country where the ultimate disposal would not conform to reasonable standards of health, safety or environmental protection. It is recommended that re-use programs focus upon retaining the material in Australia. It should be noted however, that re-use charities and other programs in Australia tend to have certain criteria about the age and processing power of the products they will accept (often computers should be less than 5 years old and have at least Pentium 3 processors).

The first and simplest means of encouraging re-use would be to communicate with the community about the options for re-use of working goods at all the same points of contact as the promotion of the e-waste recycling system (web-sites, newspaper adverts etc.). Some examples of organisations that may already receive computers and redistribute for reuse are listed in Appendix 4.

Capturing operating electronic products and diverting them to re-use rather than recycling could happen either at the point of drop off, or upon reaching the e-waste recycler. If there is space and a partnership can be created with local re-use organisations, material that is still operational could be set aside at the drop off point. If there are insufficient staff numbers to manage the diversion of re-usable material at the drop-off point it may be possible to ask the recycler to divert this material to re-use on the Local Governments behalf. Some of the recyclers in Australia have existing systems in place to repair equipment or to send operating products to re-use organisations. This option would need to be investigated as part of the overall arrangement with the recycling company.

3.5 Financial Implications of e-waste recycling systems

The cost implications for running an e-waste collection program will relate to:

- **Space** – particularly if space is required that might have been used for other activity (e.g. car parking at retail collection points or collection of another resource at local government operated sites)
- **Special equipment** - such as fork lift vehicles or trolleys

- **Security** – there may be a need for increased security to protect collected material
- **Staffing costs** - although many local government sites will have staff on site already that may be able to deal with the additional material
- **Training, data collation** and other associated activities
- **Transport to recyclers** (e.g. a transport fee of about $350 applies for transportation of a skip to depots within Perth) (costs will be affected by fuel prices)
- **Promotion** – Promotional materials can be expensive if a significant campaign is required, although initially, Local Government websites and standards means of communication can be used

The fees for actual recycling of the material will be consistent across all collection models. If a sufficient quantity of high value products (i.e. the equipment such as computers which contain high value metals) can be obtained and the units are in good condition (not smashed or contaminated) then some of the recyclers may be able to offset the high costs of recycling the 'difficult' and expensive to recycle products such as CRTs. In Victoria the Byteback program costs about $1.5 million per year in total to run, of which about $200,000 is for marketing and administration (AIIA *pers. comm.* 2008).

The assessment of the Recycle IT! program in New South Wales in 2002/03 found that reprocessing costs were the minimal part of the budget, and transport and promotion formed the greatest areas of expense (Department of Environment and Conservation, NSW, 2004). Tables 6 and 7 provide the range and average costs associated with the Recycle IT! program for the three different collection models trialled. Over the Recycle IT! trial period (November 2002 – April 2003) over 6,000 pieces of equipment were collected; this weighed about 55 tonnes (plus about 5% 'by-catch'). The permanent drop off sites accounted for 89% of the items collected.

Costs are likely to decrease as programs become better established, although the figures here are for a short-term, pilot project. The cost data indicate that permanent collection facilities provide the best value for money in terms of costs for each kg of material collected (or per item). The review of the Recycle IT program indicates the cost of actually processing the equipment is minor in comparison to those costs incurred for setting up, maintaining and promoting the collection sites and for loading and transporting the equipment, once collected.

Table 6: Average costs and revenues *per item* by collection methods: Recycle IT! NSW (2002/03)

Collection Method	Average promotion cost (range)	Average collection cost (range)	Average processing cost (range)	Average processing revenue (range)	Net average cost (range)
Permanent sites	$7.01 ($4.73 to $10.62)	$24.88 ($13.62 to $68.38)	$11.73 ($11.00 to $12.78)	-$7.90 (-$8.61 to -$7.28)	$35.73 ($23.93 to $80.62)
One-day events	$32.80 ($26.99 to $37.60)	$85.82 (78.45 to $94.72)	$10.59 ($10.05 to $11.24)	-$7.65 (-$8.25 to -$7.15)	$121.56 ($118.96 to $124.70)
Special events	$45.74 ($30.34 to $98.09)	$263.63 ($175.68 to $562.65)	$10.74 ($10.11 to $11.10)	-$7.76 (-$8.02 to -$7.30)	$312.35 ($209.10 to $663.54)

Table 7: Average costs and revenues *per kg of material collected* by collection methods: Recycle IT! NSW (2002/03)

Collection Method	Average promotion cost (range)	Average collection cost (range)	Average processing cost (range)	Average processing revenue (range)	Net average cost (range)
Permanent sites	$0.78 ($0.53 to $1.18)	$2.78 ($1.51 to $8.29)	$1.31 ($1.31 to $1.33)	-$0.88 (insignificant)	$4.00 ($2.65 to $9.78)
One-day events	$3.79 ($2.89 to $4.65)	$9.91 ($9.69 to $10.14)	$1.22 ($1.20 to $1.24)	-$0.88 (insignificant)	$14.04 ($13.35 to $14.70)
Special events	$5.21 ($3.34 to $11.87)	$30.00 ($19.34 to $68.06)	$1.22 (insignificant)	-$0.88 (insignificant)	$35.55 ($23.02 to $80.27)

Notes for Tables 6 and 7:

- Promotion included advertising, promotional collateral, endorsement by Clean-Up Australia.
- Collection included project management, site set-up, and pick-up costs.
- Processing included costs of testing, sorting, dismantling, processing, transport to end-markets and revenues from the sale of equipment, components and materials.
- The data for special events is for schools only

When assessing the value for money of one collection model over another, the value of dollars per kg of material collected (Table 7) is a useful one. However, the true economic implications of any given model will depend upon various local factors including how well promoted the activity is, fuel costs, staffing costs and the options of utilising resources such as space and staff from existing collection systems.

Table 8: Financial considerations for e-waste collection models

System	Staff FTEs per day	Equipment needed	Transport	Likely tonnage collected	Promotion	Data collection
Drop off Permanent site (local council run)	<1 (if using existing point – e.g. transfer station)	Fork lift, other loading equipment. Skips/pallets/ cages. Shrink wrap Data recording equipment	Transport to recycler - possibly interstate	2 -5 tonnes per week per site*	Permanent info on websites. Standard messages repeated as needed in press / flyers etc.	Easily computerised carried out by site staff either as material unloaded or as stacked for transport
Drop off Permanent site (Retailer locations)	< 1 (may be existing staff or new)	Fork lift, other loading equipment. Skips/pallets/ cages. Shrink wrap Data recording equipment	Transport to recycler - possibly interstate	2 -5 tonnes per week per site*	Permanent info on websites. Standard messages repeated as needed in press / flyers etc.	At unloading point
Vergeside collection	2 (Driver plus handler)	Specialised collection vehicle (plus fuel costs) Difficult to record data.	Transport to storage location. Transport to recycler - possibly interstate	0.5 -2 tonne per week	Will depend on level of separation needed by resident	At unloading point
Temporary collection days/ weeks	~2-4 (Depends upon expected numbers)	Skips/pallets/ cages. Shrink wrap Data recording equipment	Transport to recycler - possibly interstate	Variable: Redhill ~4 tonnes/day. City of S. Perth, ~0.5 t/day	Very promotion intensive. Will require updating/ redistributing	As unloaded from residents

*Estimate of collection based upon observations at local sites (with no promotion). Will vary significantly depending upon location of site and promotion of service.

The considerations outlined in Table 8 assume that there are several drop-off points in accessible areas, receiving key 'big ticket' e-waste items only. The viability and workability of the collection system will be affected by:

- The cost and quantity of material collected
- The range of materials collected
- The use of existing staff and space at drop-off locations
- For vergeside collection (if selected), introduction of an e-waste-only collection round
- The level of promotion

These points are described in detail in the following section.

3.5.1 The cost of e-waste collection:

Around the world, all e-waste collection systems have a cost implication for maintenance of the collection depots, covering transport and meeting the dismantling and recovery costs. It is clear that a system will only be workable if there is sufficient funding available from government, industry or more likely, both.

Electrical products with a high metal content (e.g. radiators, washing machines etc.) can attract a rebate from metal collection companies (depending upon metal prices at that time) if they have a relatively low proportion of plastics. If not functioning, electrical products can generally already be collected in steel bins at transfer stations.

Costs for recycling e-waste (charged either by unit or by kg) vary somewhat and can be subject to short term change in response to:

- Global markets for the reclaimed metals and plastics
- Fuel prices and other transport costs
- Labour costs (which will vary greatly depending upon whether the material is dismantled in Australia or overseas)

The most valuable metals (Platinum Grade Metals, or PGMs) are found in computers and laptops. Some recyclers are willing to provide a rebate if a disproportionately high quantity of valuable products such as personal computers and laptops are sent for recycling (the recyclers based in Singapore, TES-AMM have apparently signalled an ability to do this). However, provision of a service to residents is unlikely to produce a significantly high proportion of computers compared to TVs and other units.

The value of PGMs in the general e-waste stream is generally not sufficient to cover the collection, transport, dismantling and recovery processes involved in dealing with the other products and materials in the waste stream. For example, the cost of CRTs in older style TVs and monitors is high as these units are heavy, fragile, contain toxic materials and do not have a buoyant market for the end products. Recyclers will tend to charge $10 - $15 to recycle a CRT unit, although some recyclers spread their charges evenly amongst all products to avoid the illegal dumping of expensive items. In general, recycling of CRT TVs and monitors (which can make up about 50% (by weight) of the material collected from residents) is expensive and charges of up to $15.00 per unit are common; this can be more if the charge is calculated per kg as some (large-screen) TVs can be very heavy.

Recyclers often accept a mixture of all materials and charge a flat (per kg) rate which is calculated for an average mix and allows the valuable electronic components to offset the costs of CRTs and other 'low-grade' goods.

The current cost of recycling ranges from **about $0.45/kg to about $1.00/kg** (for mixed electronic goods).

3.5.2 Quantity of e-waste collected

Using the Byteback program in Victoria as a guide, about 10-15% of the available e-waste was thought to be collected (where total e-waste generated was calculated from IT sales data and the data in the IPSOS report, 2006). It is assumed that this figure corresponds to total e-waste disposal (for computers and peripherals only as per Byteback). This figure agrees well with the

Meinhardt (2001) information on recycling of computers and peripherals as a proportion of disposal (see also Table 3 and the discussion in Section 2.1).

Looking at sites currently collecting e-waste in the Perth metropolitan area (Local Council transfer stations), with no advertising or promotion of the service, it appears that approximately 2 tonnes of e-waste is currently collected per week which amounts to over 100 tonnes per year. Depending upon the number of sites used in Perth, the site location and the amount of promotion, it is likely that in the early stages of the e-waste collection scheme, the lower end of the anticipated range would be collected (about 2,000 tonnes per year for Perth) but this would increase as systems improved and householder awareness increased.

It is important to remember that this relatively low expected recycling rate is likely to be realistic at the start of a programme but will improve significantly as operations improve and householder awareness is raised and also that the 10-15% figure relates to computers and peripherals only, whereas the Perth scheme is likely to target televisions and other items.

3.5.3 The range of materials collected:

The collection of a wide range of electrical and electronic goods may be a goal in the long term but will require significant space, involve a variety of different end markets, raise a need for greater sorting and potentially require manual handling and storage of large white goods. As discussed in Section 3.5.1, different products have different costs associated with recycling. A discussion of the different products that could be accepted by the e-waste collection system in Perth is provided in Section 4.3.

3.5.4 The use of existing staff and space at drop off locations:

Where possible, drop-off points can be located at existing council run transfer stations to optimise the use of existing staff, space and infrastructure. At retail locations, full-time dedicated staff will probably not be needed but there will be a need to supervise busy sites and to stack, count and check goods that are deposited.

3.5.5 For vergeside collection (if selected), the introduction of an e-waste only collection round

In order to ensure that e-waste is separated effectively from other bulk waste collected at the vergeside this would probably require a dedicated e-waste collection service. Collection of e-waste as part of the general vergeside collections would be likely to result in breakage of products, contamination with other materials and would require space and staff to separate the e-waste from other material at the council depot or transfer station.

3.6 Recommendations for an e-waste collection model for Perth

Table 9 summarises some of the key considerations for each of the three main collection options (as discussed in Section 3.3). Taking into consideration the questions raised at the start of Section 3, including the motivations, key drivers (economic, environmental, operational and communicating with the local community, it seems that working towards establishing **a network of permanent drop-off locations delivers the best advantages for the majority of Perth residents**.

It is likely that some residents will live in more rural communities (e.g. in some of the EMRC Local Government areas in the Perth hills) and will not regularly travel to the major collection hubs. It is probably beneficial in these instances to run e-waste collection days according to a well publicised calendar so that residents can plan to deposit material accordingly.

Other councils, both in Australia and overseas (notably, Victoria) have ceased to collect e-waste from vergeside collections. The main driver for not continuing these collections are the health and safety risks to their staff. However, other reasons for avoiding vergeside collection include the degradation of products left in rain, sun and vulnerable to vandalism, the possibility of contaminating the area with broken e-waste materials and the perception that material left at the vergeside is 'low-grade' and not always likely to be recycled.

Some less mobile residents may not be able to access drop-off services. A pick-up service that could accommodate a variety of waste and recycling streams should probably be implemented for these people. This is not a high priority but could be rolled-out, once the broader e-waste program is well established.

Table 9: Summary of key considerations for the three main collection options

	Permanent drop off site	Vergeside collection	Collection days
Staff implications	▪ Manned site at specific hours ▪ Likely to be able to expand duties of existing staff at some sites	▪ Drivers ▪ Collection staff ▪ Sorting and unloading/ reloading at depot	▪ Need to source temporary staff from existing team / contractors ▪ will need constant staff training ▪ Lose consistency of service and data capture ▪ Staff intensive to coordinate: sites, set up, promotion & logistics
Collection and transport	▪ Collected from site on as required basis	▪ Collection vehicle - with staff, fuel, insurance costs	▪ Must be collected on the day and transported even if half load
Storage, sorting, transfer	▪ Can have designated area set aside at site for e-waste. ▪ Ideally would have cover and be secure	▪ Will still need depot area for sorting, loading and storage	▪ Logistics intensive. Everything has to happen on the day and be removed by end. Could utilise other storage if available
Risks	▪ Manual handling at site ▪ Security	▪ Health, safety, environmental risks	▪ Labour intensive
Benefits	▪ Greater control ▪ Good data capture ▪ Ability to store units ▪ Retail sites convenient	▪ Convenient for householder	▪ Can be located close to residents in a specific area ▪ Particularly useful model for more remote residents.
Potential concerns	▪ Can be space intensive Retailers may not wish to participate	▪ Difficult to collect data ▪ Material degraded by weather ▪ Lessens feeling of active participation	▪ Staff not always fully trained ▪ Set up and closing down each time – labour and cost intensive
Communication	▪ Needs to be consistent across Perth	▪ Confusion of e-waste system with other vergeside disposal material	▪ Difficult to promote effectively and get high participation. May work well if complete calendar is readily available
Cost Implications	▪ Permanent site and staff (possibly 'in-kind' costs) ▪ Communication ▪ Staff training ▪ Security ▪ Equipment	▪ Unless using existing system: new vehicle ▪ Storage ▪ Staff intensive	▪ High promotion costs ▪ Temp staff ▪ Consistent staff training

4 Operational considerations for the recommended e-waste collection scheme

4.1 Suitable locations for drop-off sites

An optimal efficiency e-waste collection system should be accessible to the maximum number of residents and small businesses, but require the minimum number of locations. Perth is a relatively sprawling city with many residents living some distance from major central locations. The challenge is to identify 'hub' locations that are already on existing travel routes for many people.

It is likely that residents from one local government area will use other districts to shop, work and also to dispose of their unwanted household waste and recyclables (non-kerbside collection goods). Many of the studies of e-waste drop-off participation found that people are more willing to transport e-waste for recycling, if it fits in with another regular activity such as shopping or taking other bulky materials to a transfer station for disposal.

4.1.1 Local Government sites

Local Government transfer stations around Perth are already well known to local residents and would seem to be a logical place to collect e-waste for recycling. The 2002/03 pilot project in New South Wales found that a significant amount of the material that was collected was bought to the site by residents wishing to dispose of the products, without realising that a recycling program existed.

The key benefits of utilising existing Local Government sites is that existing infrastructure, staff and other systems are already in place for the collection and transfer of waste and recyclables.

4.1.2 Retailer and AIIA involvement

Greater participation would be achieved if retail sites could be used to collect e-waste from the residents that are unlikely to go to transfer stations. In Victoria, *Officeworks* is a keen participant in the 'Byteback' scheme and in New South Wales, *Bunnings* and *Dick Smiths* stores were used as collection points for e-waste in the 'Recycle IT!' pilot program.

Some retailers are not always keen to act as recipients for e-waste but many view their participation in a positive light as it can reinforce the perception of their commitment to corporate social responsibility and also as the collection process can be a way of increasing 'footfall' rates of potential customers to their store.

Pilot schemes in other states (such as Byteback in Victoria and Recycle IT! in New South Wales), have benefited from the involvement of the AIIA. The AIIA now has good experience of setting up and running e-waste collection schemes and is the best (and arguably only) conduit between government and the manufacturing industry. Engagement with each individual company is likely to be onerous and difficult without the involvement of the AIIA.

4.2 On-site recommendations: storage, transfer and re-use

4.2.1 Storage and transfer options

The means of collecting, storing and transporting e-waste to the recycler will largely depend upon the options for unloading at the retailer's site and their individual preferences and will be considered in detail in the subsequent research to this project (the review of e-waste recyclers, as described in the Introduction to this report).

The main recyclers that serve the Perth area can receive material in three ways:

- Loaded into a skip
- Stacked onto pallets and shrink-wrapped
- Stacked into cages
- Stacked into shipping containers
- Direct drop-off at their depot (limited availability, without incurring a direct charge to residents)

Photo (above): e-waste stacked on pallets and shrink-wrapped

Most recyclers appear to consider stacking computers on pallets and wrapping in shrink wrap to work well in terms of protecting the units whilst in transport and being easy to unload and manoeuvre.

Some recyclers will also accept material in collected in skips and this can work well but may cause more mess. There can be a problem with CRT screens in skips as several people in the industry have indicated the likelihood that these will be smashed causing a safety risk and

limiting the ability to recycle these products well. The opportunity for good data capture (on the number, weight, type and brand of units) in skips is limited.

Shrink-wrapping of palleted products is often considered a good idea by the recyclers. Products on pallets stay intact, are easy to unload, are protected from stealing and there is a lower risk of injury on damaged goods.

Cages are a little more costly than pallets but are easy to handle and do not require shrink wrap. Cages cannot be stacked in the same way as pallets, but are often on wheels and are easier to move around. When empty and not in use, cages can be flat-packed for storage.

Use of shipping containers for large quantities of e-waste is simple and easy, provided the sites have space for the container (at both the collection site and at the recycler's depot). Shipping containers are also an easy way to keep the material dry and secure whilst it is stored at the drop-off site, prior to collection. The limiting factor here is the space and vehicles required to load/unload the containers at both the collection point and at the recycler's depot.

The e-waste products should be collected, stored and transported in such a way as to minimise breakage or degradation of materials (i.e. keep protected and dry), allow good data capture, be easy and safe for staff, not pose a local environmental or health risk and not entail excessive costs.

4.2.2 Space issues

It is difficult to predict the quantity of material that will be generated per week and to allow sufficient space for the collection and storage of products. This problem can be helped somewhat by allowing a reasonable amount of storage space and shipping materials to the recyclers once the appropriate container size is full. The City of Cockburn transfer station at Henderson collects about 30 units (TVs and computers) per week with only minimal advertising of the service via the local council.

Space may be an issue at some of the local government and retail sites. One way to control the space concern would be to provide a small area of e-waste collection at these sites, but have regular collections from the site to a larger central storage 'hub' from where the material can be collated and packed for transport to the recycler. Regional and local governments would know where sites that have sufficient space and are readily accessible by collection vehicles exist within their areas and would be best placed to recommend exact locations for collection points and central storage and transfer 'hubs'.

4.2.3 Diverting e-waste to re-use at the site

In the standard waste hierarchies, re-use is considered to have the environmental advantage over recycling. However, since re-use of electronics does not tend to significantly displace the purchase of new products and older units tend to be less energy efficient, the environmental advantage is lost.

The societal benefits of enabling a wider cross-section of the community to access computers and other technology is generally considered to be of sufficient benefit to make re-use a positive outcome for unwanted computers and other electronic goods (OECD, 2001).

It is recommended that any recycling system should link up with local re-use charities or organisations. Unwanted computers etc. can be deflected to re-use options both prior to reaching the collection site (through good promotion) and can also be sent on to re-use

organisations if they are checked and found to be working. An additional benefit is that Local Government will be able to save on transport and recycling costs of this operational equipment (some local re-use organisations are listed in Appendix 4.

4.3 Types of e-waste to collect

In order to determine the types of e-waste to collect, it is important to understand the economic, environmental, operational and communication limitations and opportunities for collection.

4.3.1 Economic considerations

Whilst economically, products such as televisions can represent a significant cost liability (as discussed in Section 3.5), the provision of a service and the environmental benefits of diverting these products from landfill will probably be more of a consideration to Local Government.

4.3.2 Environmental considerations

Key environmental drivers for setting up an e-waste recycling system include prevention of potentially toxic materials from entering landfills and reclamation of valuable resources in a safe manner. The greatest concentration of rare or toxic metals will be in the 'big ticket' electronic household items such as computers, TVs, media goods (stereos, DVD players, etc.) and computer peripherals. The environmental and health impacts of the materials found in most electronic waste is discussed in Section 1.2.

4.3.3 Operational considerations

A wide range of materials will require more storage space and staff and may involve some heavy lifting (probably requiring equipment such as forklifts which will require trained staff and other Health and Safety considerations).

The greater the variety of products, the more likely that a range of markets or recycling options will be needed, hence making the on-site logistics more complex.

Accepting products containing refrigerants (e.g. air conditioning units and fridges) will mean that degassing arrangements will be required. Many recyclers will not accept these products in the standard e-waste stream.

4.3.4 Communication and promotion

It is important that the e-waste collection system chosen focuses upon collecting materials within a relatively well-defined category for ease of communication with residents. Provided the messages are clear and consistent, communication of the types of materials accepted by the system should be relatively simple. The promotion of this service is a good opportunity to

engage householders as to the environmental implications of e-waste and the benefits of the recycling service.

4.3.5 Summary: types of electronic products to collect

It is recommended that household, 'big ticket' items are targeted to be collected by the e-waste collection service. Big ticket items include the more expensive electronic items found in the home such as computers, televisions, stereos, DVD players and computer peripherals. These products contain a high proportion of elements that are both valuable and a priority to divert from landfill. The items listed here to be collected have also been selected as they are from well-defined industry sectors with strong representative trade bodies and so have good potential for working towards a product stewardship or extended producer responsibility program.

The AIIA may be able to provide further guidance, although suggested categories to be considered might include:

- PC Boxes
- Laptops/notebooks
- Accessories (keyboards and mice)
- CRT VDUs
- LCD screens and televisions
- Computer-specific peripherals (hard drives, modems, webcams, speakers)
- Televisions
- Faxes, printers, photocopiers
- Audio equipment (stereos, hi-fis, speakers, CD-players, amplifiers, radios)
- Visual playback equipment (DVDs, videos, etc.)

Small electronic products that contain a high proportion of plastic and few potentially toxic metals should probably not be collected initially as this will be costly, but with less obvious environmental benefit. Examples of those products that should not be collected (in the early stages at least) include small kitchen appliances (toasters and kettles etc.), standard telephones, radios and personal beauty items such as hairdryers.

Communication with the system users needs to be consistent and simple to understand. Clearly defining the products accepted for collection in a way that can be understood by householders will make the system more efficient (by not having to deal with 'non-compliant' products).

The collection should be limited to a relatively small and manageable section of the e-waste stream but then may be extended to include a greater range of products at a later stage once the system is well-established.

4.4 Participation limitations

For an e-waste program to be fair and effective for residents and small business in Perth, it will be necessary to place some constraints upon use of the systems. The system may be less cost-effective if the system is over-utilised by some users. One concern is that the more expensive items to recycle (such as CRT monitors) are excessively deposited at the sites without the balance of more valuable items such as computer box units.

4.4.1 Accessibility and number of items

Placing limits on the access to the system to only residents (by asking for some proof of address) may be one way to restrict business users but this system will be difficult to regulate and would be relatively easy to find ways around. Limiting number of items deposited is a good way to ensure that large businesses do not utilise the system or that large numbers of one type of product are not deposited.

4.4.2 Fee charging

Whilst the provision of an e-waste recycling service will entail a cost to local government, many studies have shown that residents are unwilling to pay for such a service (e.g. DEC NSW, 2004; Hyder Consulting 2008). Application of even a nominal fee may be sufficient to result in e-waste being placed in general waste bins or illegally dumped. This does not mean that some of the costs could not be covered from general rates, although the local residents' willingness to pay additional fees will vary across the metropolitan area.

4.5 Communication and promotion

An effective communications campaign will maximise the community engagement, provide positive feedback and information about the benefits of e-waste recycling and ultimately maximise the quantity of material that is collected.

Communication and promotion can be very expensive. Extensive promotion will generally correlate with high participation rates assuming that the system is otherwise convenient to residents. High participation may actually be a problem in the implementation and establishment phase of the collection system and greater promotion may be better rolled-out once the system is well-established and running smoothly.

Messages in any communication campaign should be **clear, concise and consistent**. With environmental issues, positive messaging is often more effective than negative, as this can simply turn people off.

Promotional opportunities could include:

- Brochures
- Press releases
- A Ministerial launch event
- A media event to promote the one-day events

- Call centre (with a 1300 number)
- Paid or Council subsidised advertising in local newspapers
- Television adverts (can be very costly)
- Editorials in the Council section of local newspapers
- Announcements in AIIA newsletter to industry members
- Leaflet drop and direct mail to computer retailers and repair centres
- Information on AIIA and local/state government websites (including Keep Australia Beautiful Campaign)
- Educational resources for target organisations
- Directional and location signs at permanent sites and one day events (including banners for one-day events)
- Announcements in internal newsletters for target organisations

While the systems are being established, it may be beneficial to keep communication to a minimum. A wide-spread, effective campaign may generate a larger quantity of material than the collection and storage points are able to deal with. If problems are encountered in the early stages of the system, it would be most helpful to limit the number of people that may encounter the system and have a negative image of the scheme. Once the collection system is running smoothly, roll-out of a communications campaign that makes it clear what people can do and why will be beneficial to making the system effective.

Part of the communications strategy will be a consideration of the products that can be accepted. Initially, it would be simplest to restrict collection to the easily defined waste types that the community can readily understand.

4.6 Data Collection

When implementing a service or system it is important to understand how well it operates, whether it achieves the desired goals and where there is room for improvement. As such, no e-waste collection system should be implemented without some level of data collection for monitoring and evaluation purposes.

4.6.1 Relevant data to collect

Before identifying which data should be collected and how, we need to understand why we are collecting this information and what we might wish to do with it.

The main reasons for collecting data include:

- Monitoring the effectiveness of the system
- Reporting to stakeholders and residents about the achievements of the program
- Providing a means for cross-checking of charging from recyclers or other external contractors

- Obtaining valuable information on quantities of different branded products collected to inform the development of extended producer responsibility (EPR) programs

Basic data that will suit these requirements will include:

- Number of items per visitor
- Weight of each item (kg)
- Total number of units and total weight collected over a given timeframe
- Brand of each item – essential if any manufacturing liability for the cost of recycling is required (e.g. as is the case for Byteback, Victoria)
- Product category

4.6.2 Brand data collection

Depending upon the level of involvement from the electronic products manufacturing industry, data regarding product brand could be collected either from a regular sub-sample or consistently and thoroughly for each piece of equipment. Brand data collection may be undertaken either at the point of collection or by the recycler upon receipt of the unit. If the model used by the AIIA and the Byteback program in Victoria is adopted, manufacturers that partner with the scheme will pay for the recycling of all of their own-branded equipment, so fully auditable, complete brand data will be needed. If the program is established under a 'product stewardship' approach (as with Byteback-style voluntary schemes), liaison may be needed with the AIIA to establish the level of data and also data verification required from each of the brand owners.

The Environment Protection and Heritage Council (EPHC) has recognised the desire to have a national framework for collection and recycling of electronic products (with a focus on televisions and computers). In a media statement in November 2008, EPHC has said that further research into the impacts of electronic products and also acknowledged a lack of data to assist with development of a full cost-benefit analysis on the recycling of these goods (EPHC, 2008). Collection of verifiable, robust data will assist with this national understanding of the situation and hopefully, with the development of a solution.

Involvement of the manufacturers in the recycling of their end-of-life products is seen as a significant step towards better recycling of electronic waste. Manufacturers who are involved in the recycling of their products are driven to design for improved ease of dismantling and greater use of recyclable materials (e.g. in plastic casings).

In the USA, Booz Allen Consultants developed a brand sort Standard Operating Procedure (Booz Allen, 2006). This 'SOP' involved drawing up standard reporting formats that identified the material category (e.g. Desktop Computer, Monitor, TV or Laptop) listed against the likely brand names that will be received at the site; both the number of units and the weight are recorded. It is likely that over 600 different brands of electronic products could be found, of which probably 10-15 will form a significant proportion of the total material collected (there are over 500 minor computer brands in Australia which represent <1% of the total e-waste stream each).

Ideally, a data collection system will provide a list of the most common brands for each category of waste (up to 20) and also allow space for other brands to be entered. Use of an

electronic spreadsheet data gathering system would provide an easy and quick way of collecting this information and allow for the information to be very easily collated, checked and analysed.

Writing figures onto a sheet is cheap and simple (and does not run the risk of equipment failure or theft). However, it is also easy for data to be inaccurately copied or entered into the electronic system when analysis is required and can be costly in terms of requiring 'double handling' of the same data by staff: once to record the information and then again for data entry.

It is likely that about one third of the material collected will be unbranded or 'orphan' products ('orphan' products are those for which the brand owner is either no longer in existence or no longer in operation in Australia) (DEC NSW, 2004). Unbranded or orphan equipment can make up 10 – 20% of the total material collected by weight (various sources including Zwimpfer Communications 2007; DEC NSW 2004).

4.6.3 Product categories

The product categories collected will need to be determined and agreed for the purposes of the system. Data capture will be more meaningful if consistent categories are used across Perth. Currently, there are no consistent category definitions in use on a national basis as no formal scheme exists. It is likely that the product category information will be collected by the recycler upon receipt of the items as part of the standard reporting.

Keeping the categories of products accepted at the site to a minimum and to readily communicated product types will assist with preventing an excessive amount of material being collected, that will need to be sorted, logged and sent to different destinations; all of which will be potentially cost and labour intensive.

Regional Local Governments have expressed a desire to keep the system simple, but to target products that contain potentially hazardous or environmentally damaging elements. It is recommended that the scheme for Perth should target computers and computer peripherals as a minimum. Depending upon community perception, cost and considerations of environmental protection, additional products including household 'big ticket' items such as stereos, televisions and videos could also be included. Whilst the international spot-light is on computers and their toxic metal content, these other items all contain potentially dangerous materials such as cadmium, nickel, mercury, chromium and lead (Intertek, 2004).

Legislation is driving down the global use of toxic metals in electronic products (particularly from the European Union), but the quantity of electronic and electrical products purchased is steadily increasing. Collection of a relatively small number of products initially could be increased gradually to achieve greater diversion of recyclable and potentially toxic material from landfill.

The category definitions should be limited enough to reduce confusion but extensive enough to be useful for reporting purposes, particularly to key stakeholders.

4.6.4 Participant data

If there is a need to understand who is using the service, with a view to getting more information about how to ensure that a high proportion of Perth residents use the service it is useful to ask people dropping off equipment about:

- Residential suburb
- How they found out about the service?
- Would they use it again?
- Why do they think it's important to recycle e-waste?
- Did they feel that there was anything that could be improved about the service?
- Did they know what products could be recycled in this way?

This type of information could be best gathered by asking service users to fill out a questionnaire or be talked through the questions by a staff member. This type of information will probably only require a sub-sample of participants to be surveyed.

As a general rule with surveys, since time and staff are limited, then the fewer questions, the better. It's important to prioritise what is 'need to know' information and what is 'nice to know'.

Photo below: standard e-waste; awaiting sorting and packing

Conclusion and recommendations

4.7 Overview of recommendations

Across Australia, e-waste is a large, and growing problem that needs to be tackled at some point in the near future. In Western Australia, Local Government is well placed and well-coordinated (through Regional Councils) to deal with e-waste.

This report has looked at the drivers for e-waste collection and the potential collection models that could be used. Key recommendations for a municipal e-waste collection program for Perth are:

- Setting up a network of permanent drop-off locations at transfer stations and other well-used 'hubs'. Making use of existing locations would make good sense here
- Working with AIIA to develop a good partnership with retailers and IT manufacturers to allow a voluntary 'product stewardship' system to be established
- Focussing upon the collection of high value, 'big ticket' household items including computers, stereos, televisions and DVD players
- Establishing a calendar of one-day drop-off e-waste events for more remote communities that would find it more difficult to deposit material at permanent drop-off locations. This would work will if linked with household hazardous collection days.
- Collecting data about the quantity, type and brand of products deposited to monitor the effectiveness of the program and provide essential data that will inform national work on electronic equipment recycling
- Working through considerations that will establish the key drivers for the program and who the lead organisation might be (this will help maintain clear focus on the achievements of the program)
- Launching the program in a series of small stages, with perhaps only one or two sites initially and then developing an operational template that can be used for further sites
- Forming partnerships with organisations that can accept working electronic products for re-use
- Engaging the local community so that there is good understanding of the benefits of an e-waste recycling (and re-use) system, how they can use the system and what happens to the material
- Promotion should be carried out very lightly at first, until the systems are established and able to cope with significant quantities of material (there is a large quantity of material currently stockpiled in homes across WA, which could overload a new system)

4.8 Summary of motivations barriers and benefits

Several thousand tonnes of electronic waste are generated each year that local government will have to deal with either within landfills or by implementing a recycling system that will divert many of these goods to a more sustainable route. It is likely that in the absence of a full recycling scheme in Perth, many of these household electronic items are currently being either stockpiled or sent to landfill.

Motivations and barriers for e-waste recycling are generally similar to those found for general recyclables. Key differences between e-waste recycling and other recyclables are that e-waste often has a perceived value and is not thrown away so readily and also that the commitment needed to recycle is often greater as the product will need to be transported to a drop-off facility (as opposed to being placed in a kerbside bin).

Local government stands to gain several benefits from implementing an e-waste recycling system in terms of environmental outcomes, preparedness to deal with a growing waste stream and improved relationship with a community that wishes to see these materials dealt with appropriately. The conservation of valuable resources and the reduced risk of toxic metals being emitted from landfill are strong drivers for e-waste recycling. In implementing an e-waste recycling system that Local Government has control over, it is likely to displace material from existing operations that dump material (often illegally) in developing countries where health and safety standards are not so well respected as they are here in Australia.

Whilst it is well-known that metal recycling is significantly more energy efficient (on a life cycle basis) than mining raw minerals for metal production, the current lack of good data for greenhouse impacts of e-waste recycling is discussed in Appendix 3. Whilst Local Government would not stand to benefit directly from the reduction of energy needed to create products from recycled materials, on a life cycle basis metal recycling has significant greenhouse gas benefits.

4.9 Collection model recommendations

Internationally, various models for municipal e-waste recycling are used, including: drop-off points, temporary e-waste collection 'days' and vergeside collection. Table 10 provides a summary of the considerations associated with each collection system.

4.9.1 Permanent drop-off locations combined with a calendar of e-waste 'days'

It seems clear from researching other models in Australia and overseas that setting up permanent drop-off sites at existing local government transfer stations is a cost effective and practical means of collecting e-waste. In Australia, there is a good history of working with retailers and manufactures of electronic goods via a partnership with the AIIA to set up a wider network of collection points and allow manufacturers to voluntarily be involved in the scheme (as with the Byteback program in Victoria and Recycle IT! in New South Wales).

Setting up temporary e-waste collection days is a good way to allow more remote communities an opportunity to recycle their e-waste. However, drop off days can be costly and labour intensive. These days would work best if there was a calendar of events that was clearly publicised well in advance of the actual day. Ideally, the e-waste collection day could be combined with household hazardous waste collection days to improve economies of scale for setup and operation costs.

The use of vergeside collection of e-waste has a range of associated health, safety and environmental risks and is likely to collect only the least valuable form of e-waste. Vergeside collections are also unlikely to engage with residents desire to recycle as vergeside is seen as a disposal route for very low value materials and is not recommended as a good means of collecting e-waste for recycling (for further discussion see Section 3.3).

Table 10: Summary of key considerations for the three main collection options

	Permanent drop off site	Vergeside collection	Collection days
Staff implications	▪ Manned site at specific hours ▪ Likely to be able to expand duties of existing staff at some sites	▪ Drivers ▪ Collection staff ▪ Sorting and unloading/ reloading at depot	▪ Need to source temporary staff from existing team / contractors ▪ will need constant staff training ▪ Lose consistency of service and data capture ▪ Staff intensive to coordinate: sites, set up, promotion & logistics
Collection and transport	▪ Collected from site on as required basis	▪ Collection vehicle - with staff, fuel, insurance costs	▪ Must be collected on the day and transported even if half load
Storage, sorting, transfer	▪ Can have designated area set aside at site for e-waste. ▪ Ideally would have cover and be secure	▪ Will still need depot area for sorting, loading and storage	▪ Logistics intensive. Everything has to happen on the day and be removed by end. Could utilise other storage if available
Risks	▪ Manual handling at site ▪ Security	▪ Health, safety, environmental risks	▪ Labour intensive
Benefits	▪ Greater control ▪ Good data capture ▪ Ability to store units ▪ Retail sites convenient	▪ Convenient for householder	▪ Can be located close to residents in a specific area ▪ Particularly useful model for more remote residents.
Potential concerns	▪ Can be space intensive Retailers may not wish to participate	▪ Difficult to collect data ▪ Material degraded by weather ▪ Lessens feeling of active participation	▪ Staff not always fully trained ▪ Set up and closing down each time – labour and cost intensive
Communication	▪ Needs to be consistent across Perth	▪ Confusion of e-waste system with other vergeside disposal material	▪ Difficult to promote effectively and get high participation. May work well if complete calendar is readily available
Cost Implications	▪ Permanent site and staff (possibly 'in-kind' costs) ▪ Communication ▪ Staff training ▪ Security ▪ Equipment	▪ Unless using existing system: new vehicle ▪ Storage ▪ Staff intensive	▪ High promotion costs ▪ Temp staff ▪ Consistent staff training

Permanent drop-off sites clearly provide cost effectiveness and an ability to retain a high degree of control over the material collected. The use of existing transfer stations is one obvious set of site locations. Additional sites could be located at central 'hubs' that are in frequent use by residents such as shopping centres. Engagement with retailers may provide an excellent set of potential locations for drop-off points. Space at some points may be an issue, so it is recommended that there are small collection locations that can be served by a few central collection and storage areas, operated by local government in order to collate the e-waste for transport to the recycler.

4.9.2 Product categories to be collected

The key drivers for deciding which electronic products to target with an e-waste collection service are:

- To keep the most toxic materials out of landfill
- To provide the best use of valuable resources
- To provide a value for money service
- To engage with the local community

In view of the above drivers it is recommended that the high value 'big ticket' items in the household are targeted, at least in the initial stages for a municipal e-waste collection system for Perth.

Once the system is established, the viability of including a wider range of products could be assessed.

4.9.3 On-site recommendations: storage, transfer and re-use

Exact mechanisms for storage and transfer of e-waste will be largely dictated by the requirements of the recycler accepting the material. However, all recyclers have expressed a preference for the use of pallets to stack the material, which is then shrink-wrapped for protection. This allows for ease of loading and unloading, good opportunities for data capture and decreased breakage.

Products should ideally be stored at a site that is secure, dry and inaccessible to wildlife or the public out of site hours.

Where possible, functioning products should be diverted to a re-use option. Re-use of electronic equipment is socially beneficial and many organisations exist in WA that will arrange for products to be redistributed (sometimes also offering repair services). Re-use organisations in WA are listed in Appendix 4.

It is recommended that promotion and communication includes the re-use options currently available and that there is a pre-selection process at the collection sites to divert working products to re-use.

4.10 Launch of the e-waste collection system

As with any new scheme that aims to serve all Perth residents, it would be highly advantageous to deliver the service to one small area at first and use this area as a way to fine-tune the system and develop it as a template for the rest of the Perth metropolitan area.

As with any major city, Perth suburbs have a variety of characteristics, including differing housing densities, access to transfer stations or major urban centres and demographics. Ideally, the 'easiest' transfer station location should be used for the initial trial phase, so that considerations of **space, staff, access, communication, data capture, security and transfer to recyclers** is relatively straightforward. With these considerations in mind, local governments in Perth would be well-placed to identify the best initial e-waste collection points. Making use of existing e-waste collection locations and expanding to include additional Local Council transfer stations and retail sites if possible and appropriate would seem sensible.

Commencing the system in one Regional Council in Perth may work well (as a type of pilot scheme) and then rolling-out a more finely tuned version of the system to other Regions is likely to prove a useful option so that 'teething' problems can be eradicated before intensive commitments to infrastructure and system framework have been made.

Promotion of the e-waste collection program in Perth should probably remain 'low-key' until the systems are established and able to cope with relatively high volumes of material.

Once up and running, the communication messages for the e-waste recycling program should focus upon the benefits of recycling e-waste and upon where the material goes for recycling. It is likely (as can be found for other recyclables) that misinformation about the safety, environmental benefits or the reality that material is indeed recycled, can be barriers to participation.

4.11 Data collection recommendations

Data that describe the quantity (number of units and weight), product type and brand of e-waste collected and recycled by a scheme need to be collected. Data on the material collected will enable local government and stakeholders (such as EPHC) to understand the e-waste situation in Western Australia significantly better (currently, many of the assumptions for WA are made from broad estimates using national average figures.

Additional information can be gathered using small survey studies to establish an appreciation of resident perception of the value of the e-waste recycling program and the barriers and motivations to using the service.

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Appendix 1 Meta analysis of existing e-waste data to understand Perth municipal e-waste

Computers

In 2006/07, just over 600,000 households (nearly 80%) in Western Australia had access to a computer (ABS: 8146.0, 2007). This figure does not reflect the number of computers per household). It shows that since 1997, computer ownership in WA has grown by an average of **about 9% per year**.

In Western Australian 350,000 computers were purchased in 2005 alone (Hyder Consulting, 2006) (6,600 tonnes of computers). This total purchase figure may also include purchases for commercial use.

In 2005, 5% of households disposed of a computer (IPSOS, 2005). In Western Australia this is approximately 39,000 computers. However, over the same period, 10% of households purchased a computer (about 78,000 computers in WA).

The International Association of Electronics Recyclers (IAER 2003) quotes a US EPA study in which the lifespan of TVs was determined to range from 13 to 15 years, PCs from 3 to 6 years, and monitors from 6 to 7 years.

Meinhardt (2001) Page 20

Table i: Computer Sales by Community Sector:

Community Sector	% computer sales
***Households**	***17%**
Government	18%
Education	14%
Medium and small business	28%
Large corporations	23%

*Figure for households used to correct where data applies to all sectors

Table ii: Summary of Meta Analysis for e-waste generation in Table 3 in main report

	Hyder 2005	IPSOS 2005	Meinhardt 2001	Meinhardt 2004
	No. disposed of total in WA x17% (household proportion)x75% for Perth	No. of households likely to dispose of given product x no. households in Perth	Projected disposal in 2006 for all Australia - corrected for Perth households only	No households own equipment, life expectancy corrected for Perth households only
Computer boxes and laptops*	59,500 units, 1,100 tonnes	29,714 units, 713 tonnes	49,840 units	30,500 units
Printers, Monitors and Peripherals	110,000 units, 600 tonnes	36,000 monitors, 180 tonnes	*No data available*	145,000 units - all peripherals
Videos, DVDs and stereos (home media equipment)	120,000 units, 345 tonnes	*No data available*	*No data available*	150,000 units - VCR and Stereos only
Televisions	*No data available*	40,400 units, 400 tonnes	*No data available*	50,320 units

*Figure for computer minimum in Table 3 (Main Report) is taken from lowest figure calculated here, subtracting 40% that could be stockpiled/reused as per IPSOS (2005)

Approximate TOTAL e-waste generated in Perth	7,500 – 9,000 tonnes per annum	Assumption: that e-waste generation is 5-6 kg per person per year (e-waste recyclers *pers comm*.) NOTE: this is TOTAL e-waste not just electronic equipment – split between the two is unclear

Table iii: Conversions for units to weight of material

Equipment	Average weight
Computer boxes and laptops	18 kg
Printers, Monitors and Peripherals	5 kg
Videos, DVDs and stereos (home media equipment)	3 kg
Televisions	20 kg

Table iv: Predicted for future waste availability: 2011/12

Equipment	Units per year	Tonnes per year	Assumptions made for calculations
Computer boxes and laptops	60,000 - 90,000	2,700 - 4,000	*Sales will double over next 10 years, life expectancy assume 5 years, plus 5 years in re-use or storage for about half of units*
Printers, Monitors and Peripherals	180,000 – 225,000	1,000 - 1,240,000	*Life expectancy 5 years. Sales growth - double over next 10 years*
Videos, DVDs and stereos	225,000 - 1,000,000	680 - 3,000	*Life expectancy 2-5 years. Sales growth - double over next 10 years*
Televisions	50,000 - 75,000	1,000 – 1,500	*Life expectancy ~10 years. Sales growth - double over next 10 years*

As recycling becomes more common and acceptable, stockpiling habits are likely to decrease. It may be several years before a discernable difference is noted.

Figures taken from very broad data and assuming linear growth in line with common predictions.

Table v: Stockpiling of computers in Australia – comparison of Sustainability Victoria figures from survey of 1,700 households under ByteBack with the Australian Information Industry Association (AIIA) figures

	Sustainability Victoria	AIIA Minimum	AIIA Maximum
Units in storage	640,000	5,200,000	23,200,000
Tonnes	15,360	124,800	556,800
WA only	1,536	12,480	55,680
WA Residential only		2,122	9,466

Assumptions for Table v (above):

- Western Australia represents roughly 10% of the National total of computer ownership (IPSOS, 2005)
- The average weight of one computer unit is 24 kg (Hyder Consulting 2006)
- 17% of the total computer market is residential (this may not be a totally accurate representation of stockpiling behaviour comparing business to residences but no other figures are available). (Meinhardt, 2001)
- The Sustainability Victoria survey only measured households in Australia and so did not account for units stockpiled in commercial space.
- Neither survey makes it clear whether it counts computer peripherals in the survey or only the computer box unit. It is implied that the Sustainability Victoria ByteBack survey measures computer units only, however it may be that the inconsistency is simply from the measurement of computer accessories as 'units' by the AIIA figures.

Appendix 2 Data limitations

This project has been undertaken as a piece of desktop research. No novel research has been conducted as part of this work apart from to gather some observations and comments from some of the industry stakeholders. Only credible reports and data sources have been used in the development of this work. Every effort has been made to identify sources of information and to be clear about the methods used for arriving at the 'metadata' or final numbers produced by an analysis of available figures describing an aspect of e-waste and recycling.

It is not always clear how the information provided in any given report is calculated. Some of the main sources of confusion are listed here:

- Often, reports can include 're-use' in their 'disposal/recycling' figures. In this report it is assumed that this is generally not the case unless it is made clear otherwise.
- When quoting figures relating to 'computers' it is apparent that some reports are simply referring to the actual computer box unit (possibly including laptops and notebooks), while in other texts, this 'unit' may also refer to keyboards, screens, mice etc. In addition, it's not clear if one computer 'unit' is each piece of equipment separately or if each 'unit' is a functioning package of all pieces of equipment
- In most cases, figures are for total e-waste purchase/disposal and very few reports identify the data for municipal e-waste generation. This is likely to have introduced a relatively high margin of error to the figures as it is seldom clear which sector is being referred to or what proportion of the e-waste in Australia is from the municipal (residential and SME) sector.

Re-use data

Figures for re-use are notoriously difficult to gather with anything even approaching accuracy since many personal arrangements are made and it is impossible to know whether a given item is counted as re-use and then again counted as disposed of (with a lag of 2-5 years). Data that are provided in other reports are somewhat patchy and there is a general lack of consistency which highlights the inherent inaccuracy of collecting re-use data across a large population.

For this reason re-use data are not discussed in detail in this report and while it is certainly a beneficial route for unwanted electronic goods and residents should be encouraged to support re-use, putting accurate data against the extent to which this happens would require a more detailed, dedicated piece of research to be undertaken.

Appendix 3 Climate Change impacts of e-waste recycling

The method for calculating the impact of standard recyclables on greenhouse gas production is to look at the Life Cycle Assessment (LCA) of disposal options and compare recycling with the main alternative (in WA, landfill). LCA is a standard technique for measuring environmental impacts of products, activities and services to provide a useful tool for deciding which option has least impact. Of course, LCA is only one tool in a range of approaches by which to assess the environmental impact of a product or activity but it has proved useful in identifying the energy impacts (and hence CO_2-equivalent or greenhouse impacts) of the recycling of materials compared to sending them to landfill.

An LCA should be carried out according to the internationally recognised ISO 14040 series of standards. For example, the life cycle of using and creating one years' worth of plastic bags (including obtaining the petrochemicals to make plastic, transporting the bags to the outlet and disposal in a landfill) could be compared with expending greater energy at the start to create a re-usable 'bag for life' and disposing of this at the end of its useful life. The LCA would look at many aspects of a product or activity's impact upon the environment including release of known air pollutants, groundwater impacts, release of hazardous substances, destruction of biodiversity and energy use. Energy use will look at each fuel used in a certain aspect of the life cycle to assess the release of CO_2-equivalent gases (e.g. electricity from coal would have a different impact compared to electricity generated by geothermal power or by natural gas). An idea of the life cycle of a computer is provided below in Figure 1.

To make an LCA meaningful, it is important to have as relevant and accurate data as possible or the final answer may not be a true representation of the impacts. There are standard figures available for each material type and for transport options under different sets of conditions. The important factor to bear in mind is that recycling of aluminium, for instance from a house in Perth, with the specific circumstances of collection methods, energy usage in WA, transport to the point of sorting and then on to reprocessing will be different from recycling aluminium from another location with its own energy sources, transport implications and markets for the material.

When assessing the impact of electronic waste, the crucial factors to consider quickly multiply:

- There are hundreds of different product types that are electronic waste, each with different material compositions
- There are 20-30 different materials used in any one product (see table 1 in the introduction)
- These materials may be separated and sent to different locations for reprocessing
- The markets for materials may change on a regular basis, thus impacting upon transport and upon the techniques employed for reprocessing (including the energy source to undertake the reprocessing)

It is not surprising, given the factors listed above, to find that there is very sparse information about the actual greenhouse gas implications of e-waste recycling. The little information that is available is unlikely to be very relevant to the situation in Perth. It is likely that as LCA techniques develop, more information will become available, but for now it is sufficient simply to understand that overall, retaining resources and avoiding mining of raw minerals is generally agreed to be a positive thing to do.

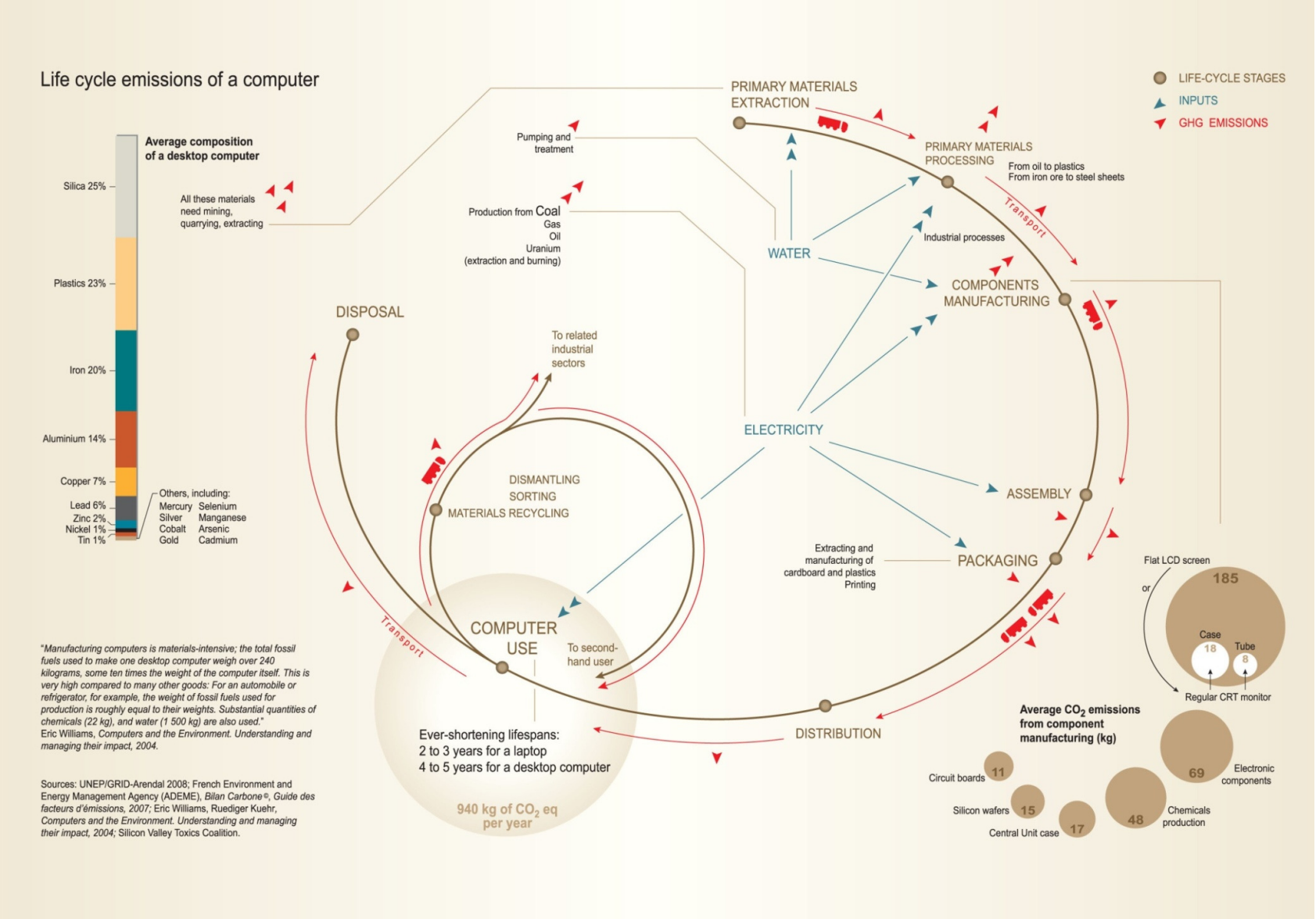
It should be noted that Sims e-recycling estimate the greenhouse impacts of recycling electronic products to be 5.46 tonnes of CO_2-e 'saved' for every tonne of e-waste that is

recycled (AIIA, *pers. comm*.). Given the energy intensity of mining, refining and smelting the metals associated with the production of electronic products, to use a figure that is of this order may be intuitively reasonable. To provide some context, recycling of aluminium saves 15 – 17 tonnes of CO_2-e per tonne, steel saves about 1.5 tonnes CO_2-e per tonne and copper would save 3-4 tonnes CO_2-e per tonne of copper recycled (figures can be found on the Sustainability Victoria website: *www.sustainability.vic.gov.au)*.

The Sims e-recycling greenhouse savings figure (5.46 tonnes of CO_2-e per tonne of e-waste recycled) is likely to relate specifically to the process used by Sims e-recycling (i.e. their means of transport and handling to specific locations etc. for their process of collection, dismantling, material recovery and transfer to markets). The Sims greenhouse gas savings figure may also relate to one specific product in the waste stream and so make certain assumptions about the age and origins of that product.

Sims e-recycling should be contacted for further information regarding the assumptions used for their calculations if this number is to be used for any assessment for reporting or communication.

Figure 1: Life Cycle Emissions from a Computer (from UNEP 2008)



Appendix 4 Examples of computer re-use partnership options in the Perth area

Program	Description	Location	Website
Computer Technologies for Schools Project	▪ Receives working computers and distributes to schools ▪ Trades non-working items for refurbishment and receives ▪ PCs can be delivered directly to schools	Nationwide: network of warehouses in each state (WA w/house in Welshpool)	http://www.ctfs.edna.edu.au/ctfs/Jahia/home/pid/267
Green PC	▪ Refurbish computers for community and sell at low cost	Drop off	https://greenpc.infoxchange.net.au/shopcart/browse.chtml
Students Without Borders	▪ 8 Ball Computer Recycling Program accepts donations of computers ▪ Distributes to student and low income community members	Computers delivered to Murdoch University	http://murdochguild.murdoch.edu.au/swb/

Source: G. Busby, DEC WA 2008 *pers. comm.*

Appendix 5 Population and area for WA local governments and Regional Councils

REGIONAL COUNCIL	MEMBERS	POPULATION*	AREA (km²)**
Eastern Metropolitan Regional Council	Town of Bassendean	13,285	11
	City of Bayswater	55,362	32.8
	City of Belmont	32,491	40
	Shire of Kalamunda	48,881	349
	Shire of Mundaring	36,931	644
	City of Swan	100,801	1,043
	TOTAL	**287,751**	**2,119.8**
Southern Metropolitan Regional Council	City of Canning	87,754	65.4
	City of Cockburn	80,921	148
	Town of East Fremantle	6,697	3.2
	City of Fremantle		18.86
	Town of Kwinana	20,812	118
	City of Melville	99,713	52.7
	City of Rockingham	91,702	261
	TOAL	**387,599**	**667.16**
Mindarie Regional Council	City of Wanneroo	124,887	687.5
	City of Stirling	189,083	100
	City of Perth	13,486	8.8
	City of Joondalup	157,203	96.8
	Town of Cambridge	25,448	22
	Town of Vincent	26,904	10.4
	Town of Victoria Park	28,738	17.62
	TOTAL	**565,749**	**943.12**
Western Metropolitan Regional Council	Town of Claremont	8,873	4.9
	Town of Cottesloe	7,223	4
	Town of Mosman Park	8,214	4.3
	Shire of Peppermint Grove	1,570	1.5
	City of Subiaco	17,835	7.1
	TOTAL	**43,715**	**21.8**
Rivers Regional Council	City of South Perth	41,572	20
	City of Armadale	53,445	560.40
	City of Gosnells	97,408	127
	City of Mandurah	55,815	173.5
	Shire of Serpentine-Jarrahdale	13426	905
	Shire of Murray	13,000	1,821
	TOTAL	**274,666**	**3606.9**
	City of Nedlands	21,852	20.6
TOTAL		**1,581,332**	**7,379.38**

*2007 Census data
**From 2006/2007 Local Government Directory