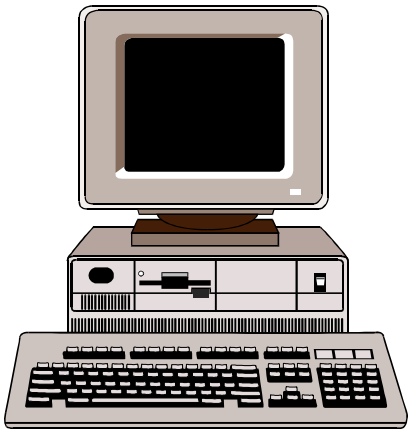
Electronics

COMMODITY PROFILE

North Carolina Department of Environment and Natural Resources
DIVISION OF POLLUTION PREVENTION AND ENVIRONMENTAL ASSISTANCE

MARKETS ASSESSMENT 1998



OVERVIEW

Electronics include computers and related equipment, televisions, telecommunication devices, and any other durable electronic goods generated by households, businesses, or industries. Electronics recovery is in its infancy, and as such, little data is available on the actual quantity of material available for recycling, or the amount being recovered.

This commodity profile focuses primarily on the reuse and recycling of computers and, to a lesser extent, televisions. Computer monitors and televisions share a critical component, cathode ray tubes (CRTs), which are leaded glass picture tubes. Because they contain lead, CRTs are classified as hazardous waste under some circumstances, yet a trend towards encouraging recycling and removing barriers to handling the material is emerging in the management of waste CRTs in the United States.

Businesses and individuals manage electronic equipment waste in a variety of ways including:

- In-house refurbishment, typically at larger businesses where equipment is repaired and reused within the same company.
- Selling or donating relatively high value used equipment to be refurbished and resold.
- Selling obsolete equipment with valuable components to be dismantled and recycled.
- Paying to recycle or dispose of obsolete equipment with little or no residual value of its components.

Although the amount of electronics available for disposal in North Carolina continues to increase, little information is available regarding the quantity of material being recovered. It appears that most large businesses have computer recycling programs in place. However, small businesses and residents appear to be lacking the knowledge of available options or the financial resources to recycle computers.

SUPPLY

Generation

Because electronics are durable goods, the supply available

for recycling is not the amount of goods shipped in a given year but rather the amount actually requiring disposal. Estimates of the number of goods requiring disposal vary widely, and North Carolina-specific numbers were not available; therefore, assumptions from several national and state-level studies were applied to North Carolina data. Figure 1 presents estimates on the range of materials available for recovery. Equipment storage complicates these calculations. Many computers, for example, are stored three to five years before disposal.

The number of total electronics and CRT-containing items available for disposal in North Carolina was estimated by applying the methodology used by the Massachusetts Department of Environmental Protection (MADEP).[1] Studies and reports estimating the amount of electronics and CRTs discarded and stored were reviewed by MADEP prior to making its in-house analysis. Those studies and the resulting estimates of the amount of electronics ready for disposal in North Carolina include:

- The Organization for Economic Cooperation and Development Study – 26,282 tons per year of CRT units.
- The Microelectronics and Computer Technology Corporation Report – 16,672 tons per year of CRT units.

This methodology attempts to account for multiple CRT-containing items per household and also accounts for storage prior to disposal. Assumptions and calculations are:

- The average household has two CRTs at 45 pounds per unit. North Carolina has 2.796 million households. Two CRTs is a conservative estimate, so these calculations may underestimate generation. [(2)(45)(2.796 million)/2000 lbs=125,820 tons]
- Life cycle of CRTs is 10 years, including use and storage. [(125,820)/10=12,582 tons] This calculation assumes that a constant number of CRT-containing items are disposed at a constant rate annually and also that as many go into storage as come out. This assumption may overestimate the amount of CRTs, as the life of a television can be significantly longer than 10 years.
- Workplaces have approximately the same number of CRTs as residences. [2(12,582)=25,164 tons].
- CRTs represent half of all electronics. [2(25,164)=50,328 tons].

Based on these calculations, at least 50,328 tons of electronics (25,164 tons from residential and a like number from commercial sources), or nearly 0.6 percent by weight of North Carolin's waste stream are ready for disposal annually. Figure 1 presents estimates of the amount of electronics requiring disposal in 1997 and the year 2002 based on a population increase of 6.1 percent as reported by the North Carolina Office of State Planning. These estimates do not include the potential Y2K effects discussed later in this Commodity Profile and assume that the conservative two CRTs per household unit estimate will hold true during this time period.

The following factors will likely increase the amount of material ready for disposal in the near term, but at the same time, make it difficult to estimate:

- *Television turnover from analog to digital.* By federal law, television broadcasts will switch from analog to digital transmission signals in 2006, accelerating the turnover of televisions, VCRs, and other analog video and audio equipment. This switch will likely cause a drop in the tonnage of analog televisions sent for repair and resale as it becomes impractical to repair and resell these TVs and may eventually relegate repaired electronics to the export market. Between 2005 and 2010, the number of CRTs in the waste stream is expected to increase as the resale and repair infrastructure shrinks. Some sources estimate that, depending on the rate of turnover, the volume of discarded electronics may jump to hundreds of thousands of tons in one year.[2]
- It is more likely, however, that the transition to digital television will be gradual, as households will not discard analog sets that can be used several more years. A recent report asserted that the broadcast

Figure 1. Estimates of the Amount of Electronics Requiring Disposal (1997 and 2002)

	1997	2002
Residential Electronics	25,164	26,699
Workplace Electronics	25,164	26,699
Total	50,328	53,398

Sources: 1) OECD = Organization for Economic Cooperation and Development
2) MADEP = Massachusetts Department of Environmental Protection
3) MCC = Microelectronics and Computer Technology Corporation
4) CMU = Carnegie Mellon University

industry intends to use dual transmission modes (both digital and analog) until at least December 31, 2006, meaning viewers will experience no change in service. [3] Further, it appears that broadcasters will continue providing analog signals beyond the 2007 deadline. Under Section 3003 of the Balanced Budget Act of 1997, Congress mandated the Federal Communications Commission (FCC) to extend the 2007 deadline for markets where 15 percent or more of the households lack digital sets.[4]

- Even after the industry has completely converted to digital transmission, inexpensive converter boxes that attach to analog sets would make it possible to receive digital signals. These converter boxes would enable viewers to continue using their analog sets for the duration of their normal useful life. This means some consumers may not be pushed as hard as originally thought into investing in new technology.[5]
- *Stored equipment*. It is virtually impossible to estimate the amount of electronic equipment stockpiled in residences. In theory, a large, immediate supply could become available as collection programs were initially implemented. Realistically, however, this stockpile would more than likely diminish over time, resulting in a smaller contribution to annual generation.
- *Year 2000 (Y2K) dilemma*. Companies may upgrade their systems to Y2K compliant machines rather than trying to "fix" their existing systems, meaning the potential exists for a significant number of old computers to be retired. According to one processor, recycling companies in the best position to take advantage of this increased supply are those that (1) can capture value out of computer systems through recycling or demanufacturing and (2) have the capability to dispose non-value items in an environmentally safe manner.[6]

Recovery

Data were insufficient to estimate recovery in North Carolina. However, of the estimated 50,328 tons of electronics generated, only a small portion is assumed to be recovered. Current recovery efforts are described in the demand section.

Regulatory Framework

A key concern in CRT management is the presence of lead. The average CRT contains about eight pounds of lead, encased in the glass screen.[7] The disposal of CRTs potentially could release lead into the environment. Disposal not only represents a potential health hazard but also the loss of a recyclable natural resource. Leaded glass recovered from CRTs can be safely and practically reprocessed to produce new CRTs.

CRTs generated by households are exempt from hazardous waste regulation. Under some circumstances, CRT-containing items generated by businesses can be classified as hazardous waste under the Resource Conservation and Recovery Act (RCRA). This waste management decision hinges on results of a toxicity characteristic leaching procedure (TCLP). Materials that fail the TCLP are classified as hazardous waste. TCLP involves crushing and grinding CRT glass, which exposes additional surface area and allows more lead to leach than from an intact CRT. Some industry analysts assert that this approach does not replicate actual conditions in a landfill. They also question whether whole products containing a CRT (e.g., a whole monitor or television) should be deemed hazardous waste, when only the CRT fails the test.[8] Black and white monitors are less likely to fail the TCLP test than color monitors.

State-level regulation of CRTs is still developing. In some states, CRTs are managed as universal wastes, meaning regulatory burdens are eased, provided proper recycling or disposal is ensured. Massachusetts is the first state to develop specific regulations. Pending approval by the U.S. Environmental Protection Agency (EPA), effective July 1, 1999, intact CRTs will be removed from the list of hazardous wastes to allow for recycling. Additionally, CRTs will be banned from disposal, and ground up or broken CRTs will remain listed as hazardous waste because of their potential to leak and disperse lead.[9] EPA Region I has not approved this approach as part of the Massachusetts RCRA program. In fact, EPA views the approach of total deregulation as being in violation of federal requirements, and has advised MA DEP that it could approve any number of compromises including handling CRTs under the Universal Waste Rule, with exclusions for CRTs heading to recyclers. Figure 2 outlines management policies in other selected states.

In North Carolina, the Hazardous Waste Section of the Division of Waste Management has outlined the following regulatory approach in a memo to a computer recycler:

- Unused, off-specification CRTs are considered non-listed commercial products, which are not regulated when reclaimed.
- Used CRTs could be considered spent materials or scrap metal if they have recoverable metal value. If the CRTs were considered spent materials, they would be considered solid wastes when reclaimed and subject to applicable hazardous waste management regulations if they were a characteristic hazardous waste. However, it is thought that intact monitors or televisions would not fail the TCLP.[10]

The Hazardous Waste Section has expressed interest in developing a guidance document for CRT management,

Figure 2. Overview of CRT Management in Selected States

State	Action
California	Regulates all CRTs as hazardous waste.
Florida	Considering a disposal ban on CRTs.
Massachusetts	Banned CRTs from landfills and incinerators, effective in 1999. The state will not consider intact CRTs hazardous waste.
Michigan	Added electric lamps to its Universal Waste Rule. Determined that CRTs fit the electric lamp definition and, therefore, may be managed as a universal waste.
Minnesota	CRTs are managed in a pilot project where no generator license or EPA identification number is needed. Has not formally adopted the Universal Waste Rule. Manufacturer responsibility is being discussed.
New Jersey	Adopted the Universal Waste Rule and is currently in the process of adding CRTs to the rule. Also pilot testing a CRT recycling facility.
Wisconsin	Special waste category exempts unwanted electronic equipment from hazardous waste regulations provided it is destined for recycling or reuse.

Source: EPR2 Conference Summary

similar to its enforcement policy for lights containing mercury.[11] Research into such a policy is ongoing, and requests from companies that recycle CRTs are increasing.

Some portion of leaded glass recovered from used CRTs can be safely and practically reused to produce new CRTs. In June 1998, the Computers and Electronics Sector Subcommittee of EPA's Common Sense Initiative (CSI) recommended revisions to RCRA to facilitate glass-to-glass recycling of CRTs. In particular, CSI recommended that EPA exclude processed CRT glass to be reused in CRT glass manufacturing from RCRA hazardous waste regulations. This option is preferred because it ensures that lead oxide remains in the glass and is reused in new CRT glass. The CSI also requested that any regulations be designed so that other legitimate recycling methods or end uses may be added in the future. These recommendations currently are being considered.

Although encouraging glass-to-glass recovery is an important first step, there are limits to this approach. Most CRTs are manufactured abroad, and it seems unlikely for economic reasons that recycled glass would be shipped from the United States to foreign nations. Additionally, there are limits to the amount of recycled glass that could be incorporated into new CRTs domestically. Experts estimate that the capacity for recycling CRT glass into new glass domestically is 150,000-300,000 tons, meaning all CRTs cannot be recycled into new CRTs.[12] Most United States manufacturing occurs in Pennsylvania, Ohio, and Indiana, making it unlikely that significant quantities could be economically transported from states outside that region. For these reasons, other markets for CRT glass must be developed.

DEMAND

Limited information exists on the total demand for discarded electronics. Demand is determined by existing recovery practices, of which only a small portion can be quantified. No data are available on the national recovery of electronics. Additionally, North Carolina's local efforts are difficult to quantify without a detailed study of the various types of recovery taking place. For example, re-sale and refurbishment could be taking place at thousands of businesses throughout the state. Also, many large corporations have in-house refurbishment and resale programs, which are difficult to quantify.

A brief summary of the different recovery options for businesses and individuals is presented below. The types of recovery include reuse, de-manufacturing, and recycling.

Reuse

Reuse of whole computer systems is the most environmentally preferable, cost effective, and well-established form of electronics recovery. Similar to automobiles, computer systems are durable goods that can have value to several different owners throughout their lifetime. Reuse includes direct reuse, upgrading, refurbishment, leasing, re-sale, and donation of usable electronics.

- **Direct reuse** occurs frequently within businesses when new computer systems are purchased and used systems are passed on to others within the organization.
- **Upgrading** a computer to a higher processing speed or adding memory allows the system to maintain its value for a longer period of time.
- **Refurbishment** of computers can range from

simple cleaning tasks to more complicated parts replacement and repair.

- **Leasing** is becoming a more common practice for computer equipment. Leasing companies typically lease computers as many times as possible, repairing the units when necessary, and sell the equipment towards the end of its useful life.
- **Re-sale** of equipment is a very common and economically beneficial means for handling electronic equipment. *The Wall Street Journal* estimates that 2.4 million used computers were sold in the United States during 1996.[13] However, many companies continue to store equipment, which not only costs money but also greatly reduces the re-sale value of the equipment. In some cases, equipment becomes obsolete, costing the company more to dispose or recycle.
- **Donating** computers to charities or other organizations is a well-established means of handling computer equipment. For companies that demand only high-end computers, the useful life of their equipment may be very short. Companies can donate computers to public schools and other institutions needing the equipment. Organizations involved in this type of program typically accept computers for free, refurbish them, and place them in schools. Depending on the value of the equipment, companies sometimes may receive a tax deduction for their donation.

Revenues/Costs: Reuse always should be practiced before recycling for both environmental and economic reasons. Reuse usually results in cost savings, if not actual revenue generation. The re-sale of personal computers typically yields revenues for systems with processing speeds of 286 or greater. The value of a computer system varies depending on the processing speed of the system, and the overall quality and reputation of the brand of computer. The re-sale value for an older 286 computer is between $25-$50 per central processing unit (CPU), and used CPUs with the relatively newer 100 Mz Pentium processors sell for $100-$300. Monitors or CRTs range from $25-$100 depending on color capability and resolution.[14]

Although the revenues for these low-end computers are minimal, they only decrease over time. Slower processing speed computers are considered to be obsolete and typically will need to be recycled or de-manufactured at a cost to the consumer.

De-Manufacturing

De-manufacturing is a type of recovery related to reuse where the computers are dismantled and stripped of their valuable parts for resale. Most commonly, memory components, integrated circuit boards, motherboards, disk drives, and CD-ROM drives are recovered for resale. These parts are collected and stored for direct resale.

Revenues/Costs: The demand for used computer parts varies depending on their compatibility with new computer systems and the cost of new parts. Previously, one of the most valuable components for resale was the random access memory (RAM) boards, with a resale value of roughly $8 per four-megabyte single in-line memory module (SIMM). However, with competition from newly developed memory components, the price has fallen to $1. Processors are a relatively high end-end component. Newer processors such as the Intel-Pentium, range from approximately $15-$100 depending on processor speed.[15] Overall, revenues from dismantling may or may not compensate for the cost depending on the total value of the components, less the cost of disposal or recycling of the residual materials. Also, market prices fluctuate and are not fixed. Thus, an activity or material that is profitable at one time may not be profitable at another time.

Recycling

Recycling is the least established and typically most costly form of electronics recovery. Recycling involves breaking down a computer into its components to recover individual recyclable commodities. This process can be completed through either dismantling with lower volumes of material or automated recycling processes with higher volumes of material. Although computer components can vary greatly by brand, one analysis of the breakdown of computer components by weight is provided in Figure 3.

Revenues/Costs: In a typical personal computer (PC), only about 55 percent of materials are considered recyclable. Figure 4 provides a rough breakdown of the value of some materials recovered from a typical PC. This information comes from a different source than the information in Figure 3 and, therefore, is not directly comparable. In this example, the total revenues generated from the sale of materials are $34.26. However, when labor, transportation, and residual disposal costs are factored in, it becomes a net loss. CRT recycling is an especially costly recycling component. The prices range from $5-$15 per unit, because of a specialized process involved in safely handling the material.

End Users/Processors

Below is a partial listing of the public and private entities involved in recovering electronics equipment from North Carolina. Many more are likely involved in some type of electronics recovery either by reuse, refurbishment, or re-

Figure 3. Components of a Computer

Components	Percent
Silica	24.90%
Plastics	23.00%
Iron	20.50%
Aluminum	14.10%
Copper	6.90%
Lead	6.30%
Zinc	2.20%
Nickel	0.85%
Other (Gold, Cadmium, etc.)	1.25%
Total	100%

Source: *MSW Management*, May/June 1998, p. 82.

Figure 4. Recoverable Components in a Typical Desktop Computer

Component	Percent(%)	Value($)
Plastics	23.00	11.73
Aluminum	6.30	9.11
Steel	20.50	4.18
Gold	0.001	6.27
Silver	0.02	1.03
Lead	6.30	1.93
Cadmium	0.01	0.01
Mercury	0.0022	0.00
Totals	56.13	$34.26

Source: http://www.libertynet.org/macredo/comelc.htm

cycling. Because of difficulty in obtaining information on all in-house electronics recovery, no total recovery figures are presented. Additionally, materials consolidated in one area may have originated in many different states, making it difficult to generate North Carolina-specific data.

A&B Recycling, Inc., Ft. Oglethorpe, Georgia, recycles approximately 60,000 to 100,000 pounds per month of computers (including CRTs) and telecommunications equipment from North Carolina. Depending on whether materials are source separated prior to entering the facility, the materials are either recycled individually, or commingled materials are ground for size reduction and shipped to overseas markets for additional separation. Plastic, glass, and other components are recycled into raw materials.[16]

ECS Refining, Greensboro, North Carolina, recycles solder residues, tin residues, precious metals, circuit boards, CRTs, and other computer components which they receive for assured destruction. Nationally the company processes approximately 15 million pounds per year of these materials, with approximately 40,000 pounds coming from North Carolina. The materials are sent to their parent company, ECS Refining Texas, LLC for processing.

Envirocycle, Inc., Morrisville, North Carolina, recycles all electronic equipment with a focus on CRTs. The company is based nationally out of Hallstead, Pennsylvania, and recently opened a CRT recycling division in Morrisville, North Carolina, just outside Research Triangle Park. The Morrisville plant also serves as a broker for electronics equipment other than CRTs. Nationally, Envirocycle recycled a total of 310,000 CRTs and televisions during 1997, recovering 24 million pounds of glass. In the first half of 1998, it recycled a total of 190,000 CRTs and televisions, recovering 14 million pounds of glass. Envirocycle separates the glass tube component from the computer monitors, and removes the coatings (lead) from the glass, before it is sold to makers of new CRTs.[17]

IBM, Research Triangle Park, North Carolina, is a manufacturer and developer of computer-related products. IBM has a re-manufacturing center located in Morrisville, North Carolina, where leased computers are brought back for refurbishment and are sold. Obsolete equipment is transported to IBM's Endicott, New York facility where several IBM national locations consolidate their equipment for de-manufacturing.

Thomson Consumer Electronics, Circleville, Ohio, is a recycler of CRT glass. Approximately six to 10 percent of its glass is recycled content, consuming 10,000 tons per year. Through its CRT glass recycling efforts, the company has recognized about eight percent energy cost savings and 40-50 percent savings on the purchase of recycled versus raw materials.[18]

Techneglas, Columbus, Ohio, and its parent company NEG, Japan, are the largest producers of faceplates and funnels for CRTs in the world, supplying such brand names as Sony, Toshiba, RCA, Philips, Zenith, Hitachi, Mitsubishi, and Panasonic. The companies currently use about five percent (15,000 tons) of recycled material in the production of their monitors each year. Techneglas uses cullet because of the cost savings over virgin material. The cost of raw material is approximately $300/ton, while recycled glass is approximately 60 to 75 percent of that cost. Technelgas officials also identified energy savings with reusing materials because the furnaces can operate at lower temperatures.[19]

Wesbell Group of Companies, Inc., Durham, North Carolina, purchased the telecommunications and electronic materials recovery facility previously owned by Nortel in May 1998. In 1997, they processed mostly in-house materials, but did accept small amounts of material from local businesses as a courtesy. Nortel (now Wesbell) handled about one million pounds of material per month, the largest portion of which was directly reused. Approximately 25 percent of materials were processed for recycling. An average of 35 people were employed last year by the facility.[20]

North Carolina State Surplus, Raleigh, North Carolina, is the state government agency responsible for refurbishing or scrapping all electronic equipment from state agencies. A central re-manufacturing operation is located in Raleigh. The facility refurbishes or de-manufactures computers depending on their reuse options. Computers that can be used in public schools are tested for quality, refurbished, then sent to the appropriate grade level depending on the schools' needs. Other equipment is processed into individual components, and materials are sold to recyclers/brokers. The facility handles approximately 10 computers per day, making it one of the largest recyclers in the state.

Other End Use Markets

Non-profit computer reuse companies manage small amounts of the electronics equipment in North Carolina. ExplorNet in Raleigh, North Carolina, is an example of a non-profit company that refurbishes computers for reuse in public schools. The organization receives donated computers from businesses and ships them to community colleges throughout the state. Technical students upgrade the systems, allowing them to learn computer technician skills. Computers are then sold to schools for a cost of $400, or approximately 25 percent of the typical cost of a new computer. Since its inception in 1997, ExplorNet's program helped build 250 computers from recycled and new parts.[21]

On-line computer equipment exchanges have developed on the Internet to facilitate the buying and selling of computers and peripherals. Some World Wide Web sites operate similarly to auctions, where the materials are sold to the highest bidder. Other sites list materials at set prices until they are purchased. Most of these programs require sellers to pay for transporting materials to the exchange for inspection prior to being listed on the site.

Exports are an important end market for electronics recycling for two reasons: (1) some export countries are less technologically advanced, and may demand electronic equipment that we consider to be obsolete, and (2) labor is typically cheaper in less developed countries. Labor is a key component in the economics of sorting the many different components of electronics equipment. For broken materials especially, it is essential to have reduced-cost labor to effectively separate the different materials. One local recycler estimated that breakage (obsolete and broken materials) has an export rate of approximately 80-90 percent for further separation by manual labor.[22] However, under the Basel Convention and OECD Council Decision, some discarded electronics can be deemed to be hazardous waste and therefore subject to restrictions on shipment to other countries, particularly lesser-developed non-OECD countries.[23]

SUPPLY / DEMAND RELATIONSHIP

Although costly, computer recycling activities are taking place at most large businesses. It is more likely for them to recycle computers than for small businesses or residents because of their ability to generate higher volumes of standardized equipment. For example, it is likely that a larger business will purchase a large number of the same type or brand of computer when updating its computer systems. These conditions make the economics of computer recycling more favorable.

Small businesses or residents are likely to generate small amounts of non-standardized equipment. Additionally, they appear to be lacking the knowledge of available options or the financial resources for computer recycling. Thus, the largest supply/demand issue currently involves the collection of materials from these two groups.

Several United States cities have undertaken pilot programs to recover electronics from households. In one study supported by the U.S. EPA's Common Sense Initiative, computers were collected from residents of San Jose, California. Usable computers were re-sold, and obsolete computers were recycled. Overall, the cost of the computer program was $142 per ton of material collected. However, this project included the export of the monitors to China for reuse and recovery. Had the project used a CRT recycler in the United States, it would have cost $584 per ton. In similar case studies, program costs ranged from $285 per ton of material collected to as much as $886 per ton.[24]

CONCLUSION

Although increasing quantities of computers and other electronics are being generated in North Carolina, recovery options are just developing. Existing efforts tend to be limited to larger businesses, leaving small businesses and residents without recycling options. Even where options exist, their equipment is typically obsolete and must be recycled, which is the most costly of the recovery options. Inevitably, increasing the quantity of electronic equipment recovered

from small businesses and residents will require substantial funding from local, state, or federal government to subsidize these programs.

RECOMMENDATIONS

The state should take the following steps to stimulate electronics recycling and ensure proper handling.

- *Develop a CRT management policy exempting CRTs from hazardous waste requirements if destined for recovery.* The state should develop a formal policy exempting CRTs from hazardous waste regulations or imposing less stringent regulations, as it has done for lights containing mercury, when these materials are destined for recovery.
- *Provide grants for establishing electronics collection programs*. The state should implement a grant program to encourage collection of electronics for reuse and recycling before they reach disposal facilities. Used electronics lose their after-market value when commingled with trash, so encouraging front-end collection of units by businesses, institutions, and municipalities helps ensure materials achieve their highest end use.
- *Develop state purchasing guidelines that support electronics recycling*. The state should explore the possibility of leasing or buying computers and other electronics from manufacturers with take-back programs. Such companies would need to have reuse and recycling programs for the returned equipment. These guidelines also should include preferences for the following: leasing programs, equipment that is recyclable or has recycled content, or equipment that exhibits other design for environment characteristics (e.g., easily upgradable, energy saving functions).
- *Educate small businesses and residents about computer recycling options.* Educating these entities about potential uses of old equipment could increase equipment value at the end of its useful life and decrease storage costs.
- *Survey current recovery efforts*. A survey of a representative sample of businesses in Research Triangle Park would provide better private sector recovery data and might identify large businesses willing to partner with smaller businesses to stimulate recovery.
- *Encourage public/private partnerships to increase recovery.* Local governments should partner with electronics recycling businesses to implement or expand recovery.

[1] MA DEP. Infrastructure Development Plan. May 1, 1998.
[2] MA DEP. Infrastructure Development Plan. May 1, 1998.
[3] MACREDO. *End-of-Life Computer and Electronics Recovery Policy Options for the Mid-Atlantic States*. p. 5.
[4] Personal communication. David Isaacs, Electronics Industry Association. November 1998.
[5] MACREDO. *End-of-Life Computer and Electronics Recovery Policy Options for the Mid-Atlantic States*. p. 5.
[6] Personal communication with Chris Altobell, Procurement Manager, United Datatech Distributors. September 8, 1998.
[7] MA DEP. http://www.magnet.state.ma.us/dep/bwp/dswm/files/crtmungi.htm.
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[14] http://www.comp-recycle.com/, http://www.cyberswap.com/UY9_1are/, http://www.recycles.com/remon.htm.
[15] http://www.cyberswap.com/UY9_1are/, http://www.comp-recycle.com/.
[16] Personal communication. Lamar Beardon, President, A&B Recycling. September 4, 1998.
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[19] Personal communication. Jeff Lowry, Techneglas. September 3, 1998.
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Personal communication with Steve Burns, ECS Refining, Greensboro, North Carolina, September 10, 1998.
[22] David Isaacs, Electronics Industry Alliance. November 6, 1998.
[23] MACREDO. *End-of-Life Computer and Electronics Recovery Policy Options for the Mid-Atlantic States*, Appendix A: Summary of Municipal Collection Programs.