The Computer Reclamation Market;

A Case Study of Private Households and Two University of California Campuses

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Prepared by:
Aaron Ezroj

Supervised by:
Dr. Vincent Crawford, UCSD Economics Department

Abstract: This paper applies economic theory to computer reclamation in the private sector and two University of California campuses. By examining failures in the private computer reclamation market, a foundation is set for improving university programs. A more in-depth comparison of computer waste management programs at UCSD and UCI follows. Previously, both universities managed their computer trash by sending it to landfills. Today, UCSD employs a salvage organization which is very economically efficient. On the other hand, UCI employs an environmental safety organization which is very environmentally sensitive. In theory, computer reclamation can be both economically efficient and environmentally sensitive. The goals of this paper are to suggest how universities can better manage their computer waste and encourage computer recycling in their respective communities.

I. INTRODUCTION

The purpose of this paper is to apply economic theory to computer reclamation. Examples from the private sector and two University of California campuses are utilized. Private households are discarding computers at an alarming rate and only a very small percentage of these machines are being recycled. This is because the computer reclamation market is troubled and current legislation is failing to correct its problems. Also, future legislation may or may not alleviate these problems.

In order to identify specific computer reclamation failures, this paper begins by examining break downs in the private household computer reclamation market in two cities: San Diego and Irvine. Then, it continues by closely inspecting computer waste management at two of the largest computer discarders in these communities: the University of California, San Diego (UCSD) and the University of California, Irvine (UCI). The difficulties these campuses encountered and responses they took to improve their waste management programs are reviewed.

Next, this paper encourages improvements in the computer recovery market. First, it tackles this aim by offering suggestions on how UCSD and UCI can internally process their obsolete computers in a more environmentally and economically sound manner. Then, the paper advocates for waste management reform by detailing how public universities, such as UCSD and UCI, can take a leadership role in computer recycling in their respective communities. Through example and computer recycling outreach initiatives these two universities will not solve all the problems of a mounting waste stream. These campuses will, however, offer information and unique recycling avenues to the general public who looks to the academic community for guidance.

II. PRIVATE "HOUSEHOLD" COMPUTER RECLAMATION

Externalities are the spillover effect associated with consumption that extends to third parties.[1] Without externalities the optimum social outcome can be achieved by markets without intervention. But when externalities are important, the optimum social outcome will not be obtained. Private computer reclamation is an important case in point. According to the National Safety Council, in California alone, more than 10,000 computers and televisions become obsolete every day.[2] Most of this waste is processed in a socially undesirable method. That is, most of it is stored or landfilled as opposed to reused or recycled.

First, many private household users tend to store their old computers. After approximately five years the average personal computer (PC) will have no value for original purchasers. So, they simply place it in their garage without losing personal utility.[3] The units, however, are not physically damaged and can still perform their original function. The only problem with these computers is that they are functionally

[1] Scott J. Callan, *Environmental Economics and Management Theory, Policy, and Applications,* Dryden, 2000, 684.
[2] Senate Bill No. 20, September 2003
[3] H. Scott Matthews, "Disposition and End-of-Life Options for Personal Computers," Carnegie Mellon University Green Design Initiative Technical Report, July 1997.

obsolete and cannot meet the increased demands of newer software. These preowned units would be valuable to computer users with lower software demands who could expand a computer's total lifespan by 1-2 years. Yet, with lack of incentives to encourage private households to donate their units to secondhand users, most will not choose this option. Instead, initial purchasers will store their PCs. With time these processing systems will lose all reuse value and become valued only for their raw materials.[4]

Second, an even more socially undesirable outcome in the private household computer reclamation market is that those consumers who decide to discard their units usually throw them in the trash rather than recycle them. This is because when an individual decides between throwing their computer in the trash and recycling it, they weigh the personal costs of each. Then, they choose the process that is least costly to them, the one that has the lower private marginal cost. Putting a computer in the trash is easy. On the other hand, recycling a computer costs private households a significant amount of time and money. Private households must figure out where a recycling center is, haul their heavy computer equipment to the facility which could be miles from their home and then pay the recycling company approximately $20-30 to for processing their waste. Thus, most people choose to trash their computers and only 20 percent of obsolete computers are currently recovered for recycling.[5] If more computers were recycled, society could retain valuable materials, which go unused in landfills. This includes fully working machines, working parts in broken machines and raw materials such as precious metals and plastic. Yet, with only a small percentage of PCs being recycled, potential benefits to society are squandered.

Finally, losing valuable materials by landfilling as opposed to recycling is not the only problem with trashing computers. Perhaps the greatest problem with landfilling these machines is the significant harm to society, the negative externalities, of putting computers in these sites. To begin with, Cathode Ray Tubes (CRTs) from computers and televisions contribute a large amount of lead to landfills, approximately 28.56%.[6] This can be very damaging, since lead can leak from municipal landfills. Of the 158 municipal landfills on the Superfund National Priority List, 22% leaked lead. When a municipal landfill leaks lead, closure and/or cleanup can cost millions of dollars. Further, the groundwater supply may become contaminated which can result in more cleanup costs and severe degradation of human health.[7] Another problem or negative externality with the excessive landfilling of computer waste is the amount of space these units are taking up. By 2005, 55 million whole PCs and 10% of scrap recycled computers will end up in landfills. They will take up a total of 170 million cubic feet.[8]

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[4] "Baseline Report on Recycling in Selected Segments of the Electronics Industry," Stanford Resources, Inc., National Safety Council, Washington, DC, 1999.

[5] Senate Bill No. 20, September 2003

[6] Timothy G. Townsend, "Characterization of Lead Leachability from Cathode Ray Tubes Using the Toxicity Characteristic Leaching Procedure," Florida Center for Solid and Hazardous Waste Management, December 1999.

[7] Hilary A. Sigman, "A Comparison of Public Policies for Lead Recycling," The RAND Journal of Economics, Autumn, 1995.

[8] H. Scott Matthews, "Disposition and End-of-Life Options for Personal Computers," Carnegie Mellon University Green Design Initiative Technical Report, July 1997.

Clearly, society would be better off with more computers being reused and recycled, and with less being stored and landfilled. The positive social benefits of reuse are not weighed heavily enough by initial purchasers who often choose to store their computers rather than donate them. Usually, individuals can donate items to secondhand users and receive tax refunds, but it is difficult to find a charitable organization that will take PCs and even harder to find one that will fill out tax refund forms as well. Also, as shown in FIGURE 1 too many individuals decide to trash their computers rather than recycle them because it costs them a great deal to recycle and practically nothing to landfill. Individuals pay for landfill problems indirectly through a small tax increase. Both positive and negative externalities are significant in this market.

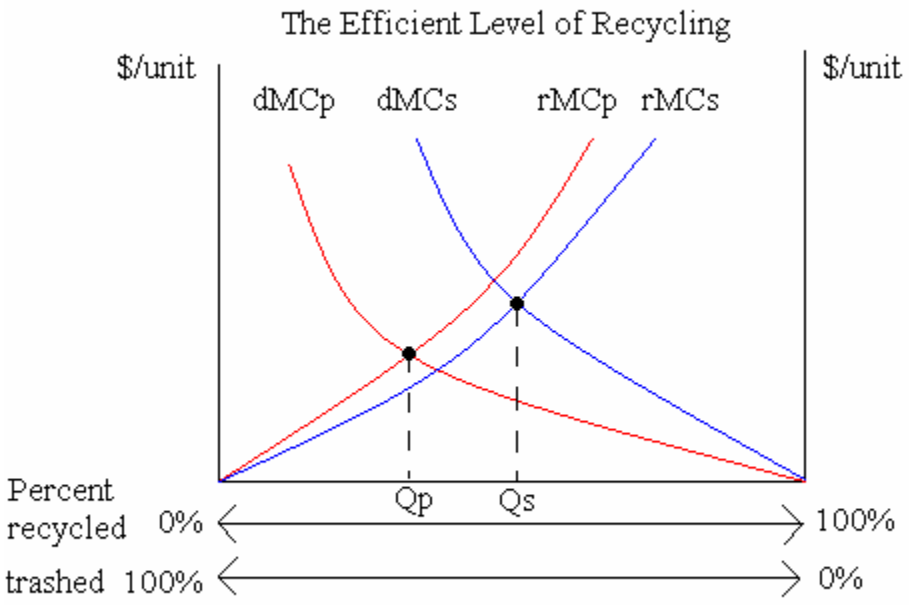

FIGURE 1

The intersection of the red lines is the private level of recycling when both positive and negative externalities are not considered by private households. The intersection of the blue lines is the socially optimal or efficient level when both positive and negative externalities are considered by private households. For the efficient level negative externalities make the marginal social cost of dumping (dMCs) higher than the marginal private cost of dumping (dMCp). For the efficient level positive externalities make the marginal social cost of recycling (rMCs) less than the marginal private cost of recycling (rMCp). As seen in this chart, the private level of recycling (Qp) is lower than the efficient level (Qs) (Modified from Tom Tietenberg, *Environmental and Natural Resource Economics*, Addison Wesley, 1988, 180.).

Since externalities are prevalent in the computer waste reclamation market, the government has tried to correct the market with legislation. Government agencies have attempted to alleviate the negative externalities of trashing by classifying CRTs as universal hazardous waste. In 1999, a study conducted by the Florida Center for Hazardous Waste Management tested 36 CRTs for lead leacheability using the U.S. EPA's toxicity characteristic leaching procedure (TCLP). The average CRT TCLP lead

concentration was 18.5 mg/L. This exceeded the 5 mg/L lead legal landfilling limit and allowed the government agencies to classify CRTs as universal hazardous waste.[9]

Reclassifying the waste resulted in several additional policy changes aimed at mitigating the harm of computer waste. But it is unclear whether these plans have affected the computer waste management market in a positive manner. First, in April of 2001, the California Department of Toxics Substances Control banned computer monitors from landfills.[10] It is unlikely however that this measure is reducing the number of private household monitors entering landfills. Clearly, monitors make their way into landfills. According to Universal Waste Special Teams at San Diego's only public landfill, Miramar Landfill, their force of six inspectors checks only 5% of the 1000 trucks that bring waste to the site and they find 2-3 monitors a day. And, this is after personal check loads at the landfill's scales.[11] Household monitors likely make it to dumps because unlike trash from companies or other large producers, trash from households is not tracked to individual polluters. Violators cannot be punished. So, punishment is not considered by an individual when they measure their private cost of trashing. Thus, computer monitors are landfilled by private households whether these machines are or are not banned.[12]

Second, to mitigate the damage of lead leachate on their facilities, recently landfills have stepped up their safety efforts. These precautions include the screening programs described above and other environmentally sound efforts, such as modifications in landfill siting and design. Although these efforts are most likely providing some lead protection for landfills, they are very costly. Such costs for landfills and costs for tax payers who pay for public facilities may outweigh these program's benefits.

Third, universal hazardous waste classifications have made processing monitors much more costly for recycling firms. This categorization and subsequent regulation placed on the waste has created barriers to entry for new firms. Expensive permits and safety precautions have led to a decrease in the number of firms entering computer recycling market and an increase in the market share for those already in it.[13] So, private households have few locations to take their computer waste and have to pay whatever price that these oligarchy-like locations demand. Residents in San Diego do not have very many places that they can take their old computer monitors and usually have to pay very high prices to recycle them. If one contacts city hall they will be referred to Miramar Recycling, RMD Technology and IMS Recycling. Miramar Recycling is located at the Miramar landfill and charges $18 per monitor. RMD Technology does not have a location in San Diego but will pick up computer parts. They charge $15 per monitor. IMS Recycling is located in Downtown San Diego and charges 25 cents a pound per monitor or approximately $10-12 each.[14]

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[9] Timothy G. Townsend, "Characterization of Lead Leachability from Cathode Ray Tubes Using the Toxicity Characteristic Leaching Procedure," Florida Center for Solid and Hazardous Waste Management, December 1999.
[10] ComputerTakeBack.com
[11] Craig Mosel, Interview, 2/26/04
[12] Miramar Landfill Special Teams, Interview, Winter 2004
[13] "Baseline Report on Recycling in Selected Segments of the Electronics Industry," Stanford Resources, Inc., National Safety Council, Washington, DC, 1999.
[14] Miramar Recycling, RMD Technology and IMS Recycling, Interview, 3/5/04

On the other hand, Irvine residents have an easier time disposing of their units. This is not because the market works properly here, but because government agencies sponsor recycling programs in this city. If one contacts Irvine city hall they will be referred to the Orange County Integrated Waste Management Board. In turn, the Orange County Integrated Waste Management Board will explain that Orange County households can dispose of their computers at no charge during the hours of 9am to 1pm on Tuesday through Saturday at locations they sponsor in four cities: Anaheim, Huntington, Irvine, and San Juan Capistrano.[15] Nevertheless, residents may not be able to recycle their computers during these limited hours.

Obviously, current legislation is flawed in several ways. New policies may not be keeping computers out of landfills. Costs of landfill safety efforts may outweigh their benefits. Also, universal hazardous waste classifications have lead to a decrease in recycling options for private households. Therefore, the government decided to intervene once again with another policy initiative: Senate Bill No. 20 (SB20). SB20 was approved by the governor of California on September 24, 2003 and filed with the Secretary of State on September 25, 2003. This bill attempts to remove the burden of electronic trash from the government and taxpayers and place it on manufacturers and customers. It is a front-end or retail disposal charge. On and after July 1, 2004, retailers must collect fee of $6 from those who purchase monitors with screen sizes of less than 15 inches, $8 from those who purchase monitors with screen sizes equal to or greater than 15 inches and less than 35 inches, and $10 for monitors with screen sizes equal to or greater than 35 inches. The tax revenue will go to the state. Then, where previously not possible, people can drop their obsolete computers off at a recycler for free rather than paying them. While some of the taxes collected from initial purchases of monitors will be used to encourage industries to create less toxic computers, such as monitors with less lead, most of the SB20 generated dollars will be redistributed to recycling firms to cover their costs.[16]

SB20 will do an excellent job of collecting tax revenue while only creating a small fraction of deadweight loss. This is because demand for monitors is inelastic since there are hardly any substitutes for them. As seen in FIGURE 2, even a very large retail disposal charge and subsequent price increase will not deter purchasing of these monitors.[17] A major concern with SB20, however, is that it does not directly target the stream of lead entering landfills. It could do so by reducing the amount of lead used in the production of monitors and encouraging more private household recycling that diverts obsolete monitors from landfills, but it does neither of these. SB20 will not reduce the amount of lead used in making monitors because waste charges are not calibrated by toxicity. With SB20 taxes are applied based on the monitor size, which does not necessarily reflect the amount of lead in the unit; notably, flat screens may contain significantly less lead than other models.[18] Thus, SB20 does little to encourage computer companies to produce computer monitors with less lead as opposed to European legislation which is successfully doing so.[19] Further, the legislation does not motivate

[15] Linda Hagthrop, Orange County Integrated Waste Management Department, 4/12/04
[16] Senate Bill No. 20, September 2003
[17] Scott J. Callan, *Environmental Economics and Management Theory, Policy, and Applications*, Dryden, 2000, 582.
[18] ComputerTakeBack.com
[19] Tom Tietenberg, *Environmental and Natural Resource Economics*, Addison Wesley, 1988, 452.

household computer owners to recycle their computers. For instance a deposit/refund system would encourage more people to bring back their monitors for recycling. Then, increased recycling would allow dealers to take advantage of previously unexploited economies of scale, resulting in lower average recycling costs and even more recycling.[20]

Instead SB20 achieves its aims indirectly. Once revenues are collected the bill proposes to redistribute these dollars in a manner that will encourage production of less toxic monitors and bolster recycling companies. If this truly occurs then the bill will achieve goals similar to those of European legislation and a deposit/refund system, and the computer recovery market will be improved. Although monitors will still enter landfills, those that do will contain noticeably less lead. Further, fewer monitors will make it to landfills because they will go to a new recycling company that was created with the assistance of collected tax dollars. If tax revenues are not used in an effective manner, SB20 will create an enormous amount of government waste. The future of the private household computer recovery market and the merit of SB20 will not rest on how many tax dollars SB20 generates, but how these dollars are spent.

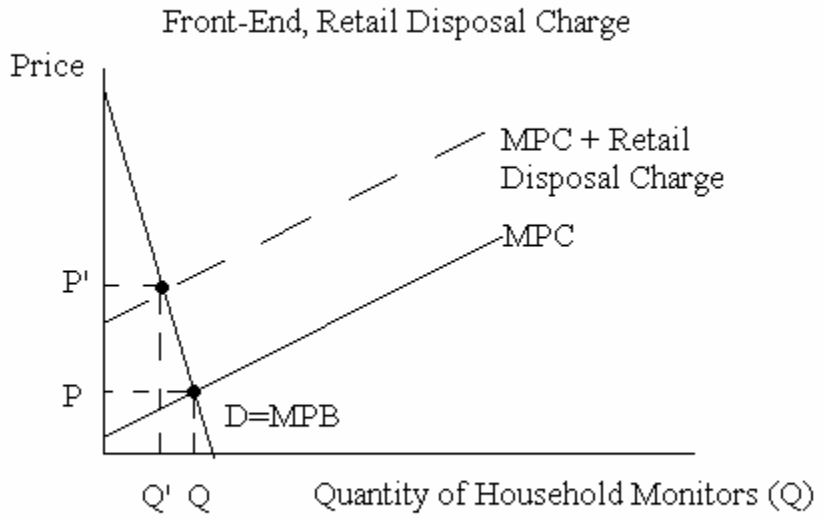

FIGURE 2

For an item with inelastic demand, such as computer monitors, even a very large retail disposal charge will only create a small decrease in the quantity of monitors purchased (Q-Q').

III. UNIVERSITY COMPUTER RECLAMATION

Like private household waste, without regulation most UCSD and UCI computer trash ended up in landfills. Before computer monitors were regulated as universal

[20] Tom Tietenberg, *Environmental and Natural Resource Economics*, Addison Wesley, 1988, 180.

hazardous waste and banned from California landfills, only a small amount of the two campuses' obsolete computer equipment was resold. Most of it was landfilled and none of it was recycled. Until March 20, 2001 very little of the roughly 3,000 computers discarded annually by UCSD departments was resold by UCSD Surplus Sales.[21] Nearly every central processing unit (CPU), monitor and peripheral (printers, scanners, keyboards, mice and speakers) was classified as solid waste and went to Miramar Landfill at the cost of $72 a ton. Further, as revealed in UCSD's last full environmental review, no computer equipment was recycled.[22] Similarly, before 2001 only very little of the computer equipment discarded annually by UCI departments was resold by UCI Salvage. The great majority of computer parts, including computer monitors, went to landfills. No computer parts were recycled prior to 2001.[23]

Current regulations affect university waste differently than private household waste. While most private household waste is not recycled, legislation has forced universities to recycle their computer waste. Because larger waste producers are watched more closely by community waste management officials and both campuses have hazardous waste management teams, UCSD and UCI quickly enacted computer reclamation programs in 2001. In March 2001, with word of impending legislation, UCSD abruptly stopped sending its computer monitors to Miramar Landfill and started stockpiling them. Then, when universal hazardous waste regulations went into effect in August 2001, UCSD began sending their computer monitors to Arizona for recycling. In 2002, 1671 CRTs were sent there for recycling.[24] The university was required to pay the recycling company, now Onyx Special Services, a substantial amount of money to recycle the waste. So, in July 2003, UCSD started sending computer monitors to the less costly Computer Recyclers of America (CRA).[25]

Today, UCSD still sends their computer monitors to CRA and within the past year has started sending peripherals to CRA as well. Computer waste management is an intricate process at UCSD. At no cost departments send their old machines to UCSD Surplus Sales. Then this salvage organization coordinates a multiple step process to extract the maximum use from reusable units and dispose of unusable units at minimal costs. For the first step, Steve Van Duine and his Surplus Sales staff let other UCSD departments bid on collected computer systems and parts. Yet, since most UCSD departments want new equipment (Pentium 3 CPUs or newer), only about 25% of the computers and monitors are moved this way.[26]

For the second step, equipment that has been passed over by departments is sold on the Surplus Sales website. Functioning Pentium 1 and 2 CPUs are bundled on pallets and sold in bulk for $10-15 and $60-85 per unit. Higher end units are sold individually. Pentium 3 CPUs with 500 mghz sell for about $150. Pentium 3 CPUs with 750 mghz sell from $200-225. Pentium 4 CPUs with 1.25 ghz sell for about $300. Monitors and other

[21] Agustin Palos, UCSD Environment, Health and Safety, Interview, Winter 2004
[22] UCSD Environmental Report, 1998; Valerie Fanning, UCSD Environment, Health and Safety, Interview, 2/10/04
[23] Kirk K. Matin, UCI Environmental Health and Safety, Interview, 4/16/04
[24] CRTs are the lead piece that is located in a computer monitor and television screen. According to Kirk K Matin in a 4/16/04 interview, 95% of the CRTs UCI Environmental Health and Safety recycles are from computer monitors and only 5% are from television screens. UCSD waste likely has a similar composition.
[25] Valerie Fanning, UCSD Environment, Health and Safety, Interview, 2/10/04 & 2/13/04
[26] Steve Van Duine, UCSD Surplus Sales, Interview, 3/10/04

equipment are also auctioned off as well. Functioning CPUs that are older than Pentium 1 models and non-functioning CPUs are bundled in electronics scrap pallets. Unsold computer peripherals are also bundled in electronics scrap pallets and with CPUs make up 70% of the bundles. Every month 6 to 8 of these pallets, reaching about 7 feet in height each, are sold to the highest bidder. Winning bids on this scrap range from $100-$200.[27] For equipment that sells for less than $50, Surplus Sales retains all revenue. For equipment that sells for $50 or more, 75% of the revenue goes back to the original department equipment owner. The remaining 25% goes to Surplus Sales.[28]

It is difficult to determine who purchases computer equipment from UCSD Surplus Sales. Van Duine says that someone from the Lion's Club purchases the Pentium 1 and 2 CPU bundles, refurbishes them and donates them to local schools.[29] Ed Siegal of IMS Recycling purchases a large number of higher end electronics, especially medical equipment and sells them on eBay.[30] Surplus Sales attempted to sell on eBay. However, the process was too time-consuming and because they could not offer warranties they were not competitive. So they stopped.[31] Those buying bundled computer scrap could be selling it abroad. The Basel Action Network, researchers for the National Safety Council and countless others postulate that similar waste is usually purchased by intermediates who then sell it abroad.

One electronics scrap pallet (Winter 2004)

For the last step, all remaining computer waste is sent from Surplus Sales to CRA. Surplus Sales sets aside computer waste with little scrap value that it cannot sell, such as those that are largely plastic and/or include a large percentage of toxins. Every month this waste fills approximately four one-cubic-yard boxes and it is picked up by CRA. Although only monitors are banned from landfills, Surplus Sales sends all unsold UCSD computer equipment to CRA. Monitors also go to CRA, such as 1612 CRTs in 2003.[32]

[27] Steve Van Duine, UCSD Surplus Sales, Interview, Winter 2004
[28] Steve Van Duine, UCSD Surplus Sales, Interview, 3/10/04
[29] Steve Van Duine, UCSD Surplus Sales, Interview, Winter 2004
[30] Ed Siegal, IMS Recycling, Interview, 3/5/04
[31] Steve Van Duine, UCSD Surplus Sales, Interview, 3/10/04
[32] Valerie Fanning, UCSD Environment, Health and Safety, Interview, 2/10/04

When Surplus Sales notifies CRA, CRA brings a truck that sends the waste to their facility. UCSD Surplus Sales is charged a stop charge of $50 for each pickup and $0.20 per pound for all the computer parts picked up.[33]

Then, CRA demanufactures the computer waste. Utilizing machinery, they separate the material by color, pull out copper wires, separate precious metals and shred plastics. Metals and plastics are sold. CRA sends materials they cannot fully process, such as circuit boards and CRTs, elsewhere. Circuit boards are sent to Electronic Partners Corporation in Los Angeles. CRTs are sent to Missouri for treatment in a lead smelter.[34] CRA and Electronic Partners Corporation, both fairly new companies, have received prestigious environmental awards and praise from recycling activists.[35]

After three weeks there are numerous monitors designated for CRA: 4 pallets, 2 half pallets, and another pallet starting. Here three pallets are pictured. (4/21/04)

Similar to UCSD, in 2001 UCI initiated a computer reclamation program. UCI Salvage managed this program by collecting computer waste from academic departments and sending monitors to ECS Refining in Santa Clara. The UCI Salvage facility sent 554 CRTs or 19,100 lbs to ECS in 2003. In June 2003, responsibility for collecting computers shifted to Environmental Health and Safety (EH&S). Now, when a UCI department discards their computer waste, they fill out a Pickup Request Form (See Appendix A) and email the form to Kirk Matin at EH&S. EH&S picks up the waste and charges academic departments for this service. Differing from Surplus Sales who picks up waste at no charge, EH&S charges departments $20 per computer monitor and $1.10/kg for all other computer parts.[36]

[33] Valerie Fanning, UCSD Environment, Health and Safety, Interview, 2/13/04
[34] Computer Recyclers of America, Interview, Winter 2004
[35] BAN.org; Sarah Westervelt, Basel Action Network, Interview, 2/2/04
[36] Kirk K. Matin, UCI Environmental Health and Safety, Interview, 4/16/04

Peripherals (4/16/04)

Waste management practices employed by EH&S are not as intricate as those used by Surplus Sales. After being recovered by EH&S, UCI computer hardware either goes directly to CRA or to UCI Salvage. If the equipment is broken EH&S takes it to their facility. Peripherals and CPUs are stored outside in boxes and on pallets. Monitors are stored in a 40 X 60 foot room inside the EH&S facility. After collecting monitors for ten months, EH&S filled up the whole room with 804 units or 29,352 lbs of waste. In April 2004, they hired a company to transport these monitors to CRA in San Diego. Computer equipment that CRA receives from UCI is processed in the same way as machines received from UCSD. If the equipment is in working condition, as indicated on the Pickup Request Form, EH&S delivers the equipment to UCI Salvage. Like UCSD Surplus Sales, UCI Salvage advertises items for sale online. But unlike UCSD Surplus Sales, UCI Salvage only sells these items in person at their facility. Also, unlike UCSD Surplus Sales, departments do not receive money for the items that UCI Salvage sells.[37]

[37] Kirk K. Matin, UCI Environmental Health and Safety, Interview, 4/16/04

Monitor storage room, once filled with 804 units (4/16/04)

In summary, both UCSD and UCI waste management programs are run by different campus branches and have slightly different focuses. A salvage organization manages UCSD's computer waste. It successfully distributes collected computer equipment to campus departments and community members who purchase these items. But in this process safety may be compromised. For instance, unsafe materials may be distributed to untrustworthy parties. Alternatively, an environmental safety organization manages UCI's computer waste. It immediately sends essentially all waste to an end-of-life waste management facility. Therefore, unsafe materials are not distributed to untrustworthy parties, but resale and reuse options are lost. Future legislation, SB20, will not greatly alter these programs. Today, UCSD departments are not charged when they discard computer waste, but UCI departments are. Because UCSD departments will be charged a tax each time they buy a monitor they will buy fewer monitors. UCI will also be charged a tax each time they buy a monitor. Yet, since this tax will likely displace the waste-end charge they are already paying, UCI departments will not buy fewer monitors. This is the only result SB20 will have on the two campuses. The bill will not improve other areas of the programs. UCSD and UCI waste management programs must change on their own because SB20 and other government legislation cannot correct market failures. In the next section, are several suggestions explaining how UCSD and UCI waste management programs can improve.

IV. RECOMMENDED UNIVERSITY IMPROVEMENTS

There are several ways that UCSD, UCI and other University of California campuses, can improve the economic efficiency and environmental sensitivity of their waste management programs. The following six actions can help universities improve their computer reclamation efforts: encourage reuse of monitors and peripherals, charge departments for computer waste management, stop selling bundled electronics scrap to unknown parties, renegotiate the price paid to CRA for taking peripherals, set up computer part swap stores and sell higher end equipment on eBay. Furthermore, as University of California schools are public universities they should encourage proper

waste management in their communities by informing the public about computer lead toxicity and recycling locations and hosting community computer recycling drives.

First, UCSD and UCI should encourage reuse of their monitors and peripherals. When departments order new CPUs they often buy them bundled with new monitors and peripheral sets. Then, when the ordered CPUs, monitors and peripherals are delivered, departments give their old functioning monitors and peripherals to university waste management officials who pay CRA to take it. Instead of paying to send thousands of functioning monitors and peripherals to CRA, UCSD and UCI waste management can give away or sell monitors and peripherals for a very low amount to university departments. It is important that UCSD and UCI departments have current CPUs that can successfully process the most current programs. But reusing older monitors and peripherals does not impede the success of these departments. If university departments will not purchase this electronics equipment, university waste recovery agencies can give away or sell monitors and peripherals for a very low amount to local schools.[38] Strict university waste regulations, however, may only make this possible with peripherals and not monitors.

Second, to improve their waste management program, UCSD should charge departments for managing the department's waste. UCI EH&S charges departments for managing department computer waste. EH&S credits this policy for reducing the amount of waste that they process, believing that departments who pay to manage their waste create less waste. Surplus Sales at UCSD should embrace UCI's policy and not continue to allow campus departments to discard their computer waste at no cost.

Third, UCSD should only allow background checked companies to bid on electronics scrap pallets. They can do this with password access bidding or contracts negotiated beforehand. At the moment, anyone can purchase large pallets of electronics scrap from UCSD Surplus Sales. All buyers need to do is make a bid online, fill out the form in APPENDIX B and pay for the item. This low level of supervision is unsettling because these pallets, although absent of monitors, include other computer parts that are potentially hazardous waste if they end up in the wrong hands. Further, it is not farfetched to believe that UCSD electronics scrap does end up in the wrong hands and is sold to demanufacturing sweatshops in third world countries. Although Steve Van Duine says that he knows two of the scrap buyers personally and they are not selling their scrap abroad, he has no way of knowing if others are. He says that it could happen.[39] Ed Siegal says that before UCSD electronics scrap may have gone abroad, but new regulations make this very unlikely.[40] Whereas an official at Miranda Recycler, a company that contracts with Hewlett Packard, says it is very likely that UCSD waste was and still is going abroad.[41] Nevertheless, electronics waste from California public agencies has been found at foreign recycling plants.[42]

Approximately 80% of all recycled computers are sent abroad for dismantling. Collectors of obsolete computers often send their computers abroad because foreign

[38] "Baseline Report on Recycling in Selected Segments of the Electronics Industry," Stanford Resources, Inc., National Safety Council, Washington, DC, 1999.
[39] Steve Van Duine, UCSD Surplus Sales, Interview, Winter 2004
[40] Ed Siegal, IMS Recycling, Interview, Winter 2004
[41] Miranda Recycler, Interview, Winter 2004
[42] Senate Bill No. 20, September 2003

companies will pay them generously for their old computers. Recycling is lucrative in developing countries where these firms exist because of low tech disassembling, limited environmental restraints, low labor costs and a demand for raw materials that cannot be produced in their country. Also, as shown in FIGURE 3 workers in developing countries value their health less and are more likely to work cheaply in unsafe computer demanufacturing plants. In addition to saving money, foreign recycling has other benefits. It provides employment and distributes resources. But, the process has big social drawbacks. Shipping hazardous waste abroad is a violation of international law established at the Basel Convention. So, continued shipping from the United States hurts our international reputation. Also, the elements of foreign electronics recycling that make it so cheap also make it very dangerous to workers and nearby villagers. At a recycling facility in China's Guangdong province, hundreds of men, women and small children break apart computers with their bare hands. Workers suffer damage to their nervous systems, brains and other organs. In nearby rivers lead levels are 190 times the drinking water standard set by the World Health Organization.[43]

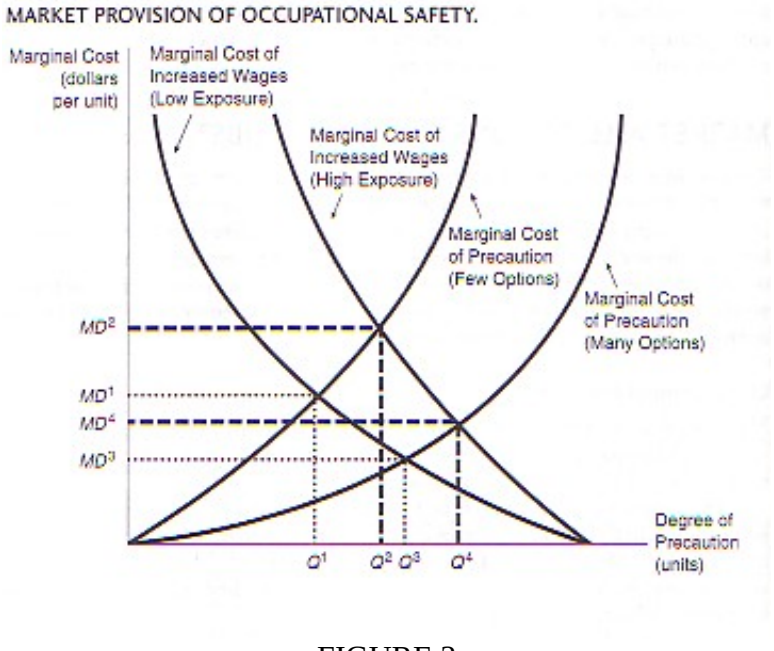

FIGURE 3

The above chart demonstrates why a worker in a developing country often ends up working under dangerous conditions and demanufacturing computers with their bare hands. These poorer workers have fewer employment options. Thus their marginal cost of precaution is higher than a worker in the United States or another developed country (Tom Tietenberg, *Environmental and Natural Resource Economics*, Addison Wesley, 2003, 478.).

Fourth, UCSD and UCI should renegotiate the amount they pay CRA to take their peripherals. UCSD Surplus Sales and UCI EH&S have peripherals which they cannot sell and are not giving away. Peripherals consist largely of plastic. Legally, both UCSD

[43] Peter Goodman,"China Serves As Dump Site For Computers," Washington Post Foreign Service 24 Feb. 2003: A1.

and UCI could just throw this material away, but toxic additives in the plastic such as flame-retardant brominated compounds make this environmentally unfriendly. [44] So, instead UCSD and UCI pay CRA $0.20 per pound to take it away and recycle it. The same fee they pay CRA to take monitors. Although $0.20 is a good rate to pay to discard monitors because monitors contain a high percentage of lead and are banned from landfills. This is not a good rate to pay to discard peripherals because peripherals contain a low percentage of lead and are not banned from landfills. The universities should look into recycling old peripherals with another recycler, such as Electronics Partners Corporation. The university should also examine hazardous waste landfilling peripherals at a rate of $0.18 per pound.[45] Toxic landfills may be a good place for this waste because this recyclable plastic is practically worthless to society anyway. Plastic gleaned from computers is poor quality material with limited potential uses. Most of it will be used to make outdoor furniture products and automobile parts, usually making up less than 25% of these products. Furthermore, recyclers typically burn or landfill 5-15% of incoming plastics because they cannot find enough companies to take it.[46]

Fifth, both UCSD and UCI should set up computer part swap stores. Carnegie Mellon is creating a "swap store" where functioning parts from broken computers can be stored and then used to replace/upgrade worn out components (e.g. hard drives, video cards, etc.).[47] Although UCSD is receiving some money for functioning computer parts by selling them in scrap bundles, they could receive more value from these parts by reusing them. Further, since UCI neither sells functioning parts as scrap nor retains them, a UCI swap store would be an excellent way for UCI to improve their economic efficiency.

Finally, UCSD and UCI should sell their higher end equipment on eBay. Surplus Sales gets more money selling lower end items on their website than eBay because this market is saturated on eBay. On higher end equipment, however, Surplus Sales loses money by not selling on eBay. Ed Siegal of IMS Recycling explains that he bought a piece of medical equipment for $1500 from UCSD Surplus Sales and resold it on eBay for $5000. He says that he makes money like this all the time.[48] Similarly, UCI should sell their higher end equipment on eBay because by not doing so they are losing money. The University of California could have one person at one university reclamation site who sells the higher end items with warranties on eBay. Individual campus reclamation services could flag higher end equipment, contact this person and ship it on eBay when it sells. The University of California could make a lot of money doing this and save time by centralizing the process.

Definitely, there are important improvements that must be made to the university reclamation programs. Making these improvements will prove to be both an economically efficient and environmentally sound decision for the universities. These reform efforts will also set a positive example for local government agencies, businesses and private households to follow. Besides improving their programs UCSD, UCI and

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[44] "Baseline Report on Recycling in Selected Segments of the Electronics Industry," Stanford Resources, Inc., National Safety Council, Washington, DC, 1999.
[45] Valerie Fanning, UCSD Environment, Health and Safety, Interview, 2/10/04
[46] "Baseline Report on Recycling in Selected Segments of the Electronics Industry," Stanford Resources, Inc., National Safety Council, Washington, DC, 1999.
[47] H. Scott Matthews, Interview, 4/7/04
[48] Ed Siegal, IMS Recycling, Interview, 3/5/04

other University of California campuses should initiate computer recycling outreach initiatives. The general public looks to the University of California for advice. People will recycle more of their computers if campuses tell them why they should and how to do so. With more community computer equipment being recycled less lead will enter landfills and millions in cleanup costs will be avoided. Since the University of California is a public university it should make the most economically intelligent decision and encourage recycling outreach now. They should inform the public about computer lead toxicity and recycling locations and host community computer recycling drives.

At the very least, community members who buy computers from the UCSD and UCI bookstores should be informed of where to properly dispose of their obsolete computers and the environmental risks of disposing of them improperly. This can be done by including a flyer with each unit they sell. On and after January 1, 2005, SB20 will force computer manufacturers to make information available on how and where to return, recycle and dispose of monitors through use of a toll-free telephone number, internet website, information labeled on the device, information included in the packaging or information accompanying the sale of the monitor.[49] The UCSD and UCI bookstores should still create a flyer because the manufacturer provided information is likely to be in small print and not detail specific San Diego and Irvine recycling sites. Including computer recycling information on the university website, especially on Earth Day, is also a good idea.

In addition to informing the public of computer lead toxicity and recycling locations, UCSD, UCI and other University of California campuses should host community computer recycling drives. The two university campuses can initiate one or more of several community recycling programs that each have different costs and benefits. Although both San Diego and Irvine can benefit from these programs, San Diego has more to gain because the city has less community recycling outreach than Irvine. One option is a Dell recycling drive. Both UCSD and UCI should look into having a Dell computer drive. Dell sets up one day computer recycling pickups at universities. An effective Dell recycling drive can extract numerous obsolete monitors and other computer parts from the community. For instance, Carnegie Mellon had a computer pick up event last year that got approximately 60 tons.[50]

A second option is city sponsored collection without reselling. UCSD and UCI could allow faculty, staff, students and/or the community to drop of their obsolete electronics units at UCSD Surplus Sales and UCI Salvage. They can allow drop offs all the time or just at certain times. Then, these two campuses could send this waste, with the campus generated waste, to CRA. Next, the cities of San Diego and Irvine would reimburse UCSD Surplus Sale and UCI Salvage for their CRA recycling costs. University of California, Santa Barbara and the city of Santa Barbara have a joint recycling program like this.[51] If the city of San Diego is ever planning to have a public funded drop site, like Irvine, piggybacking on UCSD Surplus Sales is the best option. Surplus Sales already has a recycling facility and a trained staff. By working with UCSD, San Diego avoids big permit, structural and staffing start up costs.

[49] Senate Bill No. 20, September 2003
[50] H. Scott Matthews, Interview, 4/7/04
[51] Kirk K. Matin, UCI Environmental Health and Safety, Interview, 4/16/04

A third option is salvage funded collection with reselling. This would only work at UCSD, which has the means to resell old electronics equipment. Surplus Sales could allow those with Pentium 1 or more recent computers to drop off their units for free. The revenue made from selling Pentium 1 CPUs will recoup the $6-8 UCSD must pay CRA to take the unit's monitor. Further, when higher end Pentium CPUs (2, 3 & 4s) are dropped off, the campus will not only recoup costs of recycling dropped of monitors, they will make money too. Industry experts, such as Matthews believe that it is possible to make money off of a recycling program and UCSD can do this.[52] Additionally, if UCSD is donating profits from their computer salvage drives to an important cause, like cancer research, and advertises this well, many people only looking to give their computers to a positive cause will give them to UCSD. Of course there are some problems with campus computer salvage drives. For instance people might want tax charity credit for drop offs and writing these forms may take up too much staff time. Surplus Sales, however, does not have to offer these forms or could get a local charity organization to write them for these community members. Also, storing a lot of obsolete community computers could prove impossible, but this would not be so if community drop offs were only allowed the day before or day of CRA computer pickups. Finally, hazardous waste policies may prevent UCSD from reselling donated materials. Yet, incorporating a third party who initially assumes liability for donated units (like Goodwill or IMS Recycling) may solve this problem.

At the moment many private households are storing and landfilling their computers for several reasons. Either they do not know where to take them, city recycling sites charge too much, city recycling sites are too far away, city recycling sites are open at inconvenient hours or the owners of old computers only want to give their units to a charitable causes. Through campus computer recycling outreach initiatives, computer recycling will become easier and more private households will recycle.

To reiterate, universities should:

- Encourage reuse of monitors and peripherals
- Charge departments for computer waste management
- Stop selling bundled electronics scrap to unknown parties
- Renegotiate the price paid to CRA for taking peripherals
- Set up computer part swap stores
- Sell higher end equipment on eBay
- Inform the public about computer lead toxicity and recycling locations
- Host community computer recycling drives

V. CONCLUSION

This paper opened by explaining failures in the private household computer reclamation market. It explained that because individuals view their own interests, without weighing additional costs to the general public, too many PCs are stored and landfilled and not enough are reused and recycled. Next, computer waste management

[52] H. Scott Matthews, Interview, 4/7/04

practices of UCSD and UCI were examined. Finally, suggestions were made on how the two campuses and other University of California campuses can better manage their computer waste and encourage computer recycling in their respective communities.

All of the suggestions made in this paper are important. Some of the suggestions, however, are very ambitious. For instance, setting up a computer part swap store or a campus run computer recycling program could entail a significant amount of bureaucratic maneuvering. Nonetheless, there are some very important adjustments that UCSD and UCI can easily make. These suggestions can also be followed by other University of California campuses. Campuses that sell electronics scrap bundles, such as UCSD, should only sell it to background checked companies. UCSD, UCI and other University of California campuses that sell computers should inform purchasers of where they can properly dispose of their obsolete computers and the environmental risks monitors can create if disposed of improperly. Finally, institutions that are located in communities that do not have adequate recycling facilities for private households, such as UCSD, should contact Dell and have Dell host a one time recycling drive on their campus.

Through example and computer recycling outreach initiatives these two universities and other University of California campuses will not solve all the problems of a mounting waste stream. These campuses will, however, offer information and unique recycling avenues to the general public. Then fewer PCs will be stored and landfilled and more will be reused and recycled.

APPENDIX A

Request for CRT/CED Pickup
University of California, Irvine
Environmental Health and Safety
Emergency Contact: Kirk Matin (949) 824-4578

From: <cbartley@uci.edu>
Date: Fri, 16 Apr 2004 11:58:11 -0700 (PDT)
To: kmatin@uci.edu
Subject: CRT & Consumer Devices Collocetion Request
X-UCIRVINE-MailScanner: No viruses found

Name:
Phone:
PI:
Dept: Biological Chemistry
Building: Med Sci I
Room: C-D Wing
Account:
Fund:
Email:

Unit Type: Monitor

Number of Units: 9

Consumer Electronic Device Information: Several old printers, keyboards, mouses, CPUs and monitors.

Additional Info:

Pickup Date:	Cruz	Eros	Johnson	Matin	Ritter
CRT	unit(s) x $20 per unit				
CED	kg x $1.10/kg				
Are any of these units in good working condition? YES NO					

APPENDIX B

Surplus Sales Bid Sheet

University of California, San Diego

Bidder Information

Name: _____

Address: _____

_____

Phone: _____

Email: _____

Resale#: _____

Please send this completed form to:

Mail: UCSD Surplus Sales
7835 Trade St. Suite 100
San Diego, CA 92121
Fax: (858) 578-9344

UCSD Employees Only

Employee ID: _____

Department: _____

Items Desired

Lot Number	Description	Bid Amount

Conditions of Sale

The University reserves the right to accept or reject any or all bids. At the time of sale, all items are owned by The Regents of the University of California. Please note that there is no warranty on any items sold. **All items are sold on an as is, where is basis. All sales are final.**

Upon the acceptance of a bid, full payment must be received prior to the release of the item(s). California sales tax will be applied to public sales unless a resale permit is provided. Acceptable forms of payment include cash, certified check or cashiers check made payable to **UC Regents.**

It is the responsibility of the successful bidder to remove the item(s) from the campus. The item(s) must be removed within one week of the notification of the acceptance of a bid. Expenses associated with the removal are the sole responsibility of the successful bidder.

Signature: _____ Date: _____

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