

CRB



CALIFORNIA
STATE LIBRARY
FOUNDED 1850

California Research Bureau
900 N Street, Suite 300
P.O. Box 942837
Sacramento, CA 94237-0001
(916) 653-7843 phone
(916) 654-5829 fax

Appliance Recycling and Materials Requiring Special Handling

Improving the Effectiveness of the Metallic Discards Act

By Daniel Pollak

*Prepared at the Request of Senator Debra Bowen
and Assemblymember Mervyn Dymally*

MAY 2004

CRB 04-007

**Appliance Recycling and
Materials Requiring
Special Handling**

**Improving the Effectiveness of the
Metallic Discards Act**

By Daniel Pollak

MAY 2004

ISBN 1-58703-191-4

Acknowledgements

I would like to thank Melinda Bell, an intern from the University of California Center in Sacramento, for her research assistance. CRB librarian Carolyn Zeitler also provided valuable assistance with this project. In addition, I would like to thank Trina Dangberg and Judy Hust for their assistance in the formatting and duplication of this report.

Internet Access

This paper is also available through the Internet at the California State Library's home page (www.library.ca.gov) under CRB Reports.

Table of Contents

EXECUTIVE SUMMARY	1
REQUIREMENTS OF THE METALLIC DISCARDS ACT (MDA) AND RELATED RULES.....	5
ABOUT THE MATERIALS REQUIRING SPECIAL HANDLING.....	7
USES AND REGULATION OF CFCs.....	7
USES AND REGULATION OF PCBs.....	8
USES AND REGULATION OF USED OIL.....	8
USES AND REGULATION OF MERCURY.....	8
WHICH APPLIANCES CONTAIN WHICH MRSH	9
OVERVIEW OF METALLIC APPLIANCE DISPOSAL AND APPLIANCE RECYCLING	11
STAGES IN THE RECYCLING PROCESS	11
UTILITY-SPONSORED APPLIANCE RECYCLING.....	14
WHERE AND HOW MONEY CHANGES HANDS	15
COMPLIANCE WITH SECTION 42175 OF THE MDA	17
COMPLIANCE MONITORING BY THE CALIFORNIA INTEGRATED WASTE MANAGEMENT BOARD.....	17
COMPLIANCE MONITORING BY THE DEPARTMENT OF TOXIC SUBSTANCES CONTROL ...	18
SITE VISITS DURING THIS RESEARCH	19
REASONS FOR NONCOMPLIANCE WITH SECTION 42175 OF THE MDA	20
ENVIRONMENTAL IMPLICATIONS OF NONCOMPLIANCE.....	27
ENVIRONMENTAL EFFECTS OF CFCs	27
ENVIRONMENTAL EFFECTS OF USED OIL.....	27
ENVIRONMENTAL EFFECTS OF MERCURY	27
ENVIRONMENTAL EFFECTS OF PCBs	28
ENVIRONMENTAL RELEASES OF MRSH FROM APPLIANCES	29
POLICY OPTIONS TO ADDRESS NONCOMPLIANCE.....	33
A. FEE-BASED RECYCLING AND INCENTIVES	33
B. OUTREACH AND EDUCATION EFFORTS.....	34
C. PERMITTING AND ACCOUNTABILITY	34
D. HEIGHTENED ENFORCEMENT ALONE MIGHT JUST SHIFT THE PROBLEMS.....	34
E. CLARIFICATION OF THE METALLIC DISCARDS ACT	35

F. REVISIT THE DEFINITION OF MRSH	35
G. CONSIDER EXTENDING REFRIGERATOR RECYCLING PROGRAMS	36
H. DOCUMENTING THE EXTENT OF THE ENVIRONMENTAL IMPACTS	36
GLOSSARY OF ABBREVIATIONS	39
ENDNOTES.....	41

EXECUTIVE SUMMARY

Each year in California, millions of metallic appliances are disposed of – refrigerators, freezers, washers, dryers, stoves, and similar items. The Metallic Discards Act (MDA) of 1991 (Public Resources Code Sections 42160-42185) was enacted in order to discourage the disposal of these bulky items in landfills, and to encourage their recycling.

This report is concerned with the recycling of appliances. Economic incentives and the requirements of the Metallic Discards Act have helped create a situation where most large appliances are recycled rather than put into landfills.

Many appliances contain “materials requiring special handling” (MRSH) that should be removed and properly disposed of during recycling. Removal of MRSH is required under Section 42175 of the Metallic Discards Act, which defines MRSH to include chlorofluorocarbons (CFCs), sodium azide canisters in unspent vehicle air bags, encapsulated polychlorinated biphenyls (PCBs), used oil, and mercury found in switches and temperature control devices.

However, it appears that enforcement of Section 42175 is uneven and that there are likely widespread violations. In many instances, MRSH are not being entirely removed before an appliance is recycled. In other cases, it is probable that MRSH are removed from the appliance, but not properly handled or disposed of according to relevant hazardous waste rules.

Compliance with Section 42175 is probably strongest for CFCs, due both to the economic value of CFCs and the additional regulation of them by the federal government. Compliance is probably weakest for removal of mercury switches/thermostats and PCB capacitors.

There are a number of likely reasons for noncompliance with Section 42175. Until recently, it was not entirely clear who was supposed to enforce Section 42175. It is now clear that enforcement is the responsibility of the Department of Toxic Substances Control (DTSC) and local enforcement agencies. However, there are still ambiguities in the language of the Metallic Discards Act, particularly with regard to exactly who is supposed to comply with Section 42175 and when.

In addition, the economics of recycling do not provide strong incentives to properly remove and dispose of all the MRSH. The only really valuable components that pay for their own recovery are the scrap metal and the CFCs. Also contributing may be the relative inconvenience of identifying, removing and correctly disposing of some of the MRSH, and perhaps a lack of knowledge on the part of recyclers and local regulators.

Enforcement of the Metallic Discards Act is mostly left up to local agencies. However, according to a survey we conducted of local enforcement agencies, many of them haven't kept track of all of the companies and facilities in their jurisdiction that process appliances for recycling. If they do inspect or otherwise verify compliance at these

operations, they frequently don't verify the removal of all the kinds of MRSH listed in the Metallic Discards Act. It appears that the focus of many local enforcement agencies is on enforcing the laws on known hazardous waste generators – but if a company fails to comply with Section 42175, it may not be registered as a hazardous waste generator at all, and thus may escape attention.

There is strong circumstantial evidence to infer that violations of the Metallic Discards Act lead to the release of harmful substances into the environment. There is also some evidence that compliance with the Metallic Discards Act has helped reduce PCBs contamination of wastes produced by metal shredding operations. But there is little solid information available about the extent of the environmental harms from appliance disposal. Unless more information can be developed about environmental impacts, it will be difficult to say with any precision what the benefits would be of achieving higher levels of compliance.

In addition, it should be noted that the rate of environmental release of some MRSH from appliances (in particular, mercury and PCBs) is likely to eventually diminish over time. These components are generally found only in older appliances. Over time there will probably be fewer and fewer such appliances in service or entering the waste stream.

This report concludes with several policy options and recommendations.

- 1) Compliance might be improved by providing economic incentives. It might be possible to levy recycling fees on new appliance sales or manufacture, in order to fund recycling programs or provide a bounty for recovered MRSH. However, it is not clear how an equitable system could be developed, given that much of the MRSH is only present in old appliances that are no longer manufactured or sold.
- 2) Accountability under the Metallic Discards Act could be clarified by creating a system that requires processors removing MRSH to be licensed, and requires shredders to only accept appliances with a certification from the licensed party that the MRSH has been properly removed.
- 3) The state could undertake new efforts to educate and guide local agencies in enforcement of the Metallic Discards Act, such as updating its appliance recycling guide, and its list of recycling companies.
- 4) Heightened enforcement of the Metallic Discards Act may just move problems from one part of the system to another. There are potentially millions of parties who could be violating the Act, and enforcement actions on one group can increase the economic incentives of others to violate the law. Therefore, it seems likely that an effective change would require not only increasing enforcement but also tightening the rules to make accountability clearer, and/or altering the economic incentives.
- 5) The language in Metallic Discards Act Section 42175 should be clarified to make it clearer when MRSH must be removed from appliances and by whom.

- 6) The Metallic Discards Act contains discrepancies between its treatment of appliances and its treatment of vehicles that are potentially confusing and don't have any obvious policy rationale.
- 7) The definition of MRSH includes encapsulated PCBs, but it does not appear to be feasible for recyclers to identify which appliances contain PCBs. It would be more in keeping with actual practice to require that recyclers remove any capacitors that *might* contain PCBs (metal-encased capacitors).
- 8) Extending the kind of refrigerator recycling programs now offered by the major utilities to more California households might help to promote both sound appliance recycling and energy efficiency. However, these programs are too narrow in scope to be viewed as an overall solution to the problems described in this report.

REQUIREMENTS OF THE METALLIC DISCARDS ACT (MDA) AND RELATED RULES

The Metallic Discards Act (MDA) defines “metallic discard” as “any large metal article or product, or any part thereof, including, but not limited to, metal furniture, machinery, major appliances, electronic products, and wood-burning stoves.”¹ Typical metallic discards include refrigerators, stoves, clothes washers and dryers, and air conditioners.

The MDA has two main parts: (1) restrictions on disposal of metallic discards, and (2) requirement to remove materials, which require special handling (MRSH).

The MDA prohibits solid waste facilities from accepting major appliances, vehicles, or other metallic discards, and prohibits their disposal on land or in mixed municipal solid waste. However, these restrictions only apply if the waste facility operator determines there is enough metal in the metallic discards so that it would be economically feasible to salvage them.²

This report is mainly concerned with the other main part of the MDA, the removal of MRSH. The Act requires that “materials requiring special handling” be removed from major appliances and vehicles “prior to crushing for transport or transferring to a baler or shredder for recycling.”³ The definition of MRSH consists of a list of potentially harmful or hazardous items:

- Sodium azide canisters in unspent vehicle air bags,
- Encapsulated polychlorinated biphenyls (PCBs) in appliances,
- Chlorofluorocarbons (CFCs) in air conditioners and refrigerators,
- Used oil in major appliances, and
- Mercury found in switches and temperature control devices in appliances.⁴

When the MRSH are removed, the facilities that remove them become hazardous waste generators. The enforcement of these requirements – both the requirement to remove the MRSH and the laws governing hazardous waste generators – falls within the jurisdiction of the California Department of Toxic Substances Control (DTSC). Throughout most of the state, this authority is delegated to local agencies that are known as Certified Unified Program Agencies (CUPAs). CUPA hazardous waste programs are usually city or county agencies such as fire departments or environmental health and safety programs.

Under state law, hazardous waste generators usually must have a California Environmental Protection Agency (EPA) waste generator identification number. They must comply with various rules concerning how much waste can be accumulated onsite, how it must be labeled and contained, and they must meet various other training, safety, record-keeping and contingency planning requirements.⁵

ABOUT THE MATERIALS REQUIRING SPECIAL HANDLING

In this section I will describe the Materials Requiring Special Handling (MRSH) found in appliances – what sorts of appliances they are found in and why. I will also describe how they are regulated as hazardous materials.

USES AND REGULATION OF CFCs

Chlorofluorocarbons (CFCs) are synthetic compounds used as a refrigerant and for many other purposes as well.* They were introduced as safe, chemically stable alternatives to the refrigerants sulfur dioxide and ammonia. They are regulated today because they have been found to deplete the earth's ozone layer.

Household refrigerators and freezers made prior to 1994 used a chemical called CFC-12 (also known as R-12 and by the brand name Freon).⁶ There are many other types of CFCs. CFC-114 is found in a small percentage of refrigerators. Some dehumidifiers and window A/C units may contain CFC-500 or CFC-502. New refrigerators probably not yet in the waste stream contain HFC-134a, which doesn't harm the ozone layer.⁷ Also regulated, as CFCs are Hydrochlorofluorocarbon (HCFC) compounds such as HCFC-22, commonly used in window and central A/C.⁸

Under California regulations, CFCs are not considered hazardous wastes if they are reused or recycled. Several California air districts have also adopted policies concerning the use and recycling of CFCs.⁹

In 1987, the United States signed the Montreal Protocol on Substances that Deplete the Ozone Layer. The Protocol called for a freeze in CFC production, and phased reductions in use. Since 1996, manufacture or importation has been banned in the United States.¹⁰

Section 608 of the U.S. Clean Air Act prohibits individuals from knowingly venting ozone-depleting compounds into the atmosphere while maintaining, servicing, repairing or disposing of air-conditioning or refrigeration equipment. The U.S. Environmental Protection Agency (EPA) is authorized to assess fines of up to \$25,000 per day per violation of the Clean Air Act.^{11†}

All persons recovering refrigerant from appliances must register with the U.S. EPA, and have recovery equipment that meets EPA standards. EPA rules also require persons who take the "final step in the disposal process" to either recover any remaining refrigerant or verify that the refrigerant has been evacuated. The verification must include a signed statement from the person from whom the appliance is obtained that identifies who

* Uses of CFCs have included blowing agents for foam insulation and foam packaging, use in cleaning agents, in aerosol sprays, and in fire extinguishers.

† Federal rules also regulate the venting and disposal of some refrigerants that don't deplete the ozone layer, such as Hydrofluorocarbons (HFCs).

recovered the refrigerant and when.¹² The EPA enforces these requirements with physical inspections of facilities, appliances, and records.

USES AND REGULATION OF PCBs

Polychlorinated biphenyls (PCBs) are oily fluids containing a mixture of up to 209 individual compounds.¹³ In appliances they are present in capacitors. A capacitor is an electrical component that stores electricity and helps an electric motor to operate more smoothly by minimizing voltage fluctuations.¹⁴ PCBs are also found in the ballasts of fluorescent light fixtures. A ballast is a capacitor used to supply high voltage to start the fluorescent lamp.¹⁵

Beginning in 1979 U.S. EPA banned the manufacture and sale of PCBs. Small capacitors were permitted to stay in service for their remaining useful life.¹⁶ Appliance makers were given an extension to use up their remaining stock of PCB-containing capacitors.¹⁷

Generators of PCB wastes are regulated by the state and federal governments as hazardous waste generators. Under California law, discarded PCB capacitors must be incinerated in an approved incinerator or placed into a hazardous waste landfill.¹⁸

USES AND REGULATION OF USED OIL

Oil is used as a lubricant in motors, such as those found in refrigerators (to drive the compressor) and in washing machines. California law requires that used oil be managed as a hazardous waste. This means, among other things, that generators must comply with rules regarding the transport, accumulation, and storage of the oil. A state EPA waste generator identification number is required for each site where used oil is used or accumulated. The generator must contract with a registered hazardous waste transporter to pick up the oil.¹⁹

Householders who change their own oil are exempt from these requirements, but must take their oil to an authorized collection center. Small generators may take limited amounts (up to 55 gallons) to an oil collection center as well.²⁰

USES AND REGULATION OF MERCURY

Mercury-containing switches and thermostats can be found in gas ranges, chest freezers, and in ranges and clothes washers.²¹ Mercury switches are usually used in doors, lids, or hatches – when the door or lid is opened, the mercury switch turns something on or off – such as a light or a washing machine motor. Mercury components are usually only found in older appliances, but were not completely phased out of American automobile manufacture until 2003.²² Recent California legislation bans the sale of autos containing mercury switches beginning January 2005.²³

As for disposal, mercury from appliances, when found in thermostats and switches, is regulated as “universal waste.” The term “universal waste” refers to wastes that are very common and may be subject to simplified rules.²⁴

Households and small generators are required to send mercury universal waste to a facility authorized to collect, recycle or dispose of it. They are not, however, required to have a hazardous waste generator ID number from California EPA. Small generators are defined as those having no more than 5,000 kilograms of universal waste at a time²⁵ (a threshold that is probably large enough to encompass most if not all appliance recyclers). Until February 2004, some universal wastes, including thermostats, could be disposed of into the trash by those small generators who generated less than 100 kg per month of hazardous wastes.^{26*}

Generators of less than 100 kg per month of universal wastes are generally also exempt from requirements that apply to other hazardous waste generators requiring labeling of wastes, training of employees, tracking and record-keeping, and response to spills and releases.[†] Those who generate more than 100 kg per month are, however, subject to these requirements. But no California EPA waste generator identification number is required for universal wastes except for large quantity handlers, who have more than 5000 kg of universal wastes stored onsite at any time. Few if any businesses that recycle appliances would fall into this category.²⁷

Beginning in 2006, discarded appliances that contain mercury switches will be classified as hazardous wastes even if they have not yet been removed from the appliance. In 2005, the same will apply to discarded vehicles that are about to be crushed, baled or shredded.²⁸

WHICH APPLIANCES CONTAIN WHICH MRSH

One of the challenges of complying with or enforcing the MDA is knowing which appliances are likely to contain the MRSH.

The following table shows which types of MRSH can be found in which kinds of appliances. In some cases it is easy to predict where MRSH will be found – for instance, nearly all refrigerators now in the waste stream contain CFCs and oil. However, with PCBs and mercury, it is harder to predict. In general, these are found in some older appliances, but not all of them.

* For acutely hazardous wastes, the threshold is 1 kg rather than 100 kg, but mercury switches and thermostats are not considered acutely hazardous.

† These generators are classified as “Conditionally Exempt Small Quantity Universal Waste Generators.”

Table 1: Materials Requiring Special Handling by Appliance Type

Appliance	Possible Special Materials			
	CFCs	PCB Capacitors or Ballasts*	Oil	Mercury Switches or Thermostats
Refrigerator	X	X	X	
Freezer	X	X	X	X**
Window A/C	X	X	X	
Central A/C	X	X	X	
Dehumidifier	X		X	
Microwave		X		
Clothes Washer			X	X**
Fluorescent Lighting		X		
Gas Stove				X
Water Heater				X

*Found only in some older appliances, as these components were not manufactured after 1979. Capacitors are rare in refrigerators and freezers.

**Found in some older washers and chest-style freezers

Sources: CIWMB Appliance Recycling Guide, June 1998; interviews with recyclers

OVERVIEW OF METALLIC APPLIANCE DISPOSAL AND APPLIANCE RECYCLING

The appliance recycling process begins when a household or other owner decides to discard a used appliance.* It ends with a facility known as a shredder grinding the appliances (along with discarded automobiles and other scrap material) into small pieces. The shredded scrap is separated into different kinds of metal, then sold for processing into steel and other metal products.

STAGES IN THE RECYCLING PROCESS

The recycling process can be divided into three stages: (1) Hauling and Collection; (2) Processing for Recycling; and (3) Shredding.

1) Hauling and Collection

When a household disposes of an appliance, the owner or someone else will usually take it to a centralized facility that collects discarded appliances. This can happen in a variety of ways, for example:

- The owner hauls the appliance to a landfill or other waste collection facility.
- A program sponsored by a municipal government or a utility company picks up the appliance from the household or the curbside.
- An appliance dealer such as Sears recommends a hauler or recycling company to customers that will pick up their used appliances when the customers purchase new ones.
- The owner arranges with a private hauler or scrap peddler to take the appliance away.
- The owner illegally dumps the appliance. Eventually, the county or other local government may collect it from where it was dumped.

Appliances may accumulate at a variety of locales – including county or municipal solid waste landfills and transfer stations, appliance recycling companies, and scrap yards.

At landfills, some proportion of discarded appliances are permanently dumped with other trash, but the majority are recycled. The Metallic Discards Act (MDA) allows landfill disposal of large appliances only if it is economically infeasible to recycle them. Nevertheless, some appliances do end up in landfills. This may be more prevalent in rural areas, which would have to incur higher transport costs to get their scrap appliances to a buyer.

* The great majority of discarded appliances come from households rather than businesses.

According to estimates provided to me by an appliance recycling industry consultant, based on appliance industry sales data and market research, nearly 3.3 million appliances were likely disposed of in California in 2002, as detailed in the following table.²⁹

Table 2: California 2002 Estimated Appliance Discards

Appliance	Number Likely Becoming Scrap or Waste
Refrigerators	461,191
Compact Refrigerators	Not available
Freezers	42,232
Ranges	313,905
Microwave Ovens	867,586
Clothes Washers	390,869
Clothes Dryers	337,328
In-Sink Disposers	352,561
Dishwashers	333,816
Trash Compactors	3,821
Room Air Conditioners	147,133
Dehumidifiers	24,905
Water Heaters	Not available
Central A/C	Not available
Residential Furnaces	Not available
TOTAL	3,275,349

This is only a rough estimate, but it seems fairly consistent with a 1991 CIWMB estimate of 3.4 million appliances discarded per year.³⁰

According to the CIWMB, major appliances accounted for 23,257 tons of the trash deposited into landfills in 1999.³¹ We can compare this to the amount of appliances discarded. According to the above estimate, 3.275 million appliances were discarded in a single year. Based on the average weights of each appliance type, this represented about 224,500 tons.³²

We should be cautious about comparing numbers generated using different methods for different years. Still, a comparison gives us a rough idea of relative scale – 23,257 tons going into landfills in a single year represents about 10 percent by weight of our single-year estimate of the amount of appliances discarded.

Most of the appliances that don't go into the landfills are recycled as scrap, but some that still work or can be refurbished are re-sold. One recycler told me that about 20 percent of the discarded appliances they receive from customers of a large appliance retail chain are subsequently re-sold to other countries such as Mexico. Another expert I asked estimated that up to 35 percent of discarded appliances could be re-sold rather than recycled.

It appears, then, that most large metallic appliances are ultimately recycled for scrap metal rather than simply discarded in landfills – perhaps 80-85 percent of them. The recycling rate has been increasing in the past decade.³³

2) Processing for Recycling

Recycling generally requires appliances to be fully or partially dismantled.

To properly remove chlorofluorocarbons (CFCs), a piercing valve is attached to the tubing that contains the refrigerant. The refrigerant is extracted and transferred to a storage tank.³⁴

Capacitors are cylindrical objects, usually located near the appliance motor or compressor. Once located, they can be removed with ordinary tools such as a screwdriver, wrench, and wire cutters. However, there is no easy way of telling for sure if a given capacitor contains (PCBs), so some recyclers remove all metal-encased capacitors. Mercury switches and thermostats may be found in a variety of appliances, in a variety of locations. As with capacitors, they can be removed with ordinary tools once located.³⁵

Used oil in refrigerators is found in the compressor motor. After the refrigerant has been removed, most recyclers cut the lines and wires and remove the compressor. The oil is then extracted by making a hole in the oil reservoir of the compressor and draining it into a container.³⁶

Because these materials are all regulated, a recycler who is in compliance with the law will usually have them picked up for disposal by a permitted hazardous waste transporter. The CFCs are sold to a company specializing in CFC recycling. Sometimes the oil is sold to a company that recycles oil.

When MRSH are removed from appliances, this processing may occur at the appliance collection point – a landfill, a scrap yard, a recycling company, etc. However, scrap yards, landfills, and other collectors sometimes will not accept appliances unless materials such as the CFCs and compressors have been removed beforehand. Shredders who purchase scrap appliances also have such policies. This creates an incentive for those further up in the chain to remove these components.

There are a few specialized companies that can be hired or contracted with to carry out the dismantling, including the removal and disposal of MRSH. Some operate their own dismantling facilities, while at least one of them operates by dispatching employees to a landfill or other collection site.

Appliances are sometimes crushed or baled prior to being shredded. Baling involves cutting the appliance into pieces and then bundling them into bales. Crushing or baling makes the transportation of bulky appliances more efficient.

3) *Shredding*

The majority of recycled appliances are shredded by a handful of companies known as “auto shredders.” Auto shredders operate a hammer mill, a machine that cuts crushed appliances and cars into fist-sized scraps of metal. There are five major auto shredders in the state that handle both automobiles and appliances. In addition, there are an unknown number of smaller shredders that probably only shred smaller items such as appliances.

After shredding, the scrap metal is separated into ferrous and non-ferrous metals.* It is sold, often overseas, and melted down to be fashioned into new products. In addition to shredded metal, the hammer mill creates shredder waste, also known as “fluff,” that consists of plastic, rubber, foam, and other non-metallic components. The fluff is often chemically treated and then sold as landfill cover.

The major shredders in the state employ radiation detection devices to ensure that no radioactive devices are mixed in with the appliances, and workers at various stages act as load checkers to examine incoming loads for MRSH.³⁷ The large shredder that I visited distributed to its suppliers a Scrap Acceptance Policy stating that the company would not accept materials containing MRSH. They also required suppliers to sign a certification stating that all refrigerants such as CFCs will be removed and recovered prior to delivery.

In 2001, DTSC estimated that automobiles represented about 47 percent of shredder feedstock, and the remaining 53 percent comprises appliances and other steel-containing scrap. The proportion of appliances relative to autos appears to be increasing.³⁸

UTILITY-SPONSORED APPLIANCE RECYCLING

As already noted, the recycling system involves a great variety of different kinds of companies and individuals. A role is also played by California’s three large investor-owned utilities, San Diego Gas and Electric, Southern California Edison, and Pacific Gas and Electric. All of these companies operate appliance recycling programs that are intended to encourage customers to discard old, inefficient refrigerators and freezers and replace them with more energy-efficient units.

The service areas covered by these utilities encompass about 70 percent of California households, meaning that most California households are eligible to have old refrigerators that are still in working order taken away by a reputable recycler. The service is free to households – in fact, they often receive a small (~\$35) incentive payment. By one estimate, the utility-sponsored programs recycled 51,975 refrigerators and freezers in California in 2003.³⁹ These programs only deal with appliances that are still in working order, so they do not provide a potential recycling choice for most discarded refrigerators.

* Ferrous metal – mainly steel – contains iron and can be separated with magnets. The non-ferrous metals are primarily copper and aluminum.

WHERE AND HOW MONEY CHANGES HANDS

If the MRSH are properly removed and disposed of, the value of the recyclable materials in a typical appliance is not generally sufficient to cover all the costs of recycling. Nevertheless, recycling becomes economically feasible with a small per-unit payment or subsidy to the recycler, especially with large volumes.

About 80 percent of the weight of a typical appliance is recyclable metals.⁴⁰ Scrap metal prices fluctuate widely, meaning that the economic incentives to recycle are highly variable from year to year. Prices are currently high – perhaps at an all-time high – due largely to demand from Asia. Large recyclers which can supply a reliable flow of clean, high-quality scrap fetch higher prices. One of these, a major recycler in Southern California, currently gets about \$100/ton for scrap metal (up from \$45 a ton in 1998).⁴¹

Another source of revenue for recyclers is the recovered refrigerant from refrigerators. The manufacture of CFCs has been banned due to their ozone-depleting effects in the atmosphere. This has created a strong market for recovered CFCs. According to an industry consultant I contacted, the price for CFC-12 from refrigerators ranged from \$11.30 to \$13.00/pound in 2003.⁴² These prices are also highly variable. The price for recovered CFCs was higher a few years ago – \$25-30/pound in 1998.⁴³ A typical refrigerator may contain about six ounces of CFCs.

Because the value of the recycled materials does not offset the costs of recycling, the household that disposes of an appliance often has to pay to have it removed. A household that arranges to have their appliance picked up by an appliance dealer, municipal waste collection service or special hauler will often face a fee in the neighborhood of \$15-35.⁴⁴ Sometimes these costs are subsidized by local government.* Where a pickup service is not available, a household will face a similar fee if it drops an appliance off at a landfill, or takes it to an appliance recycling company.

The cost of dismantling appliances varies. Recyclers that handle larger numbers benefit from economies of scale and can charge lower prices. There are also variations in the methods and thoroughness of the dismantlement and recycling process. A landfill I visited paid a private contractor \$11 per refrigerator to remove the CFCs and drain the waste oil. Refrigerator recycling programs for utilities may charge anywhere from \$75 to \$150 per unit. This may include costs such as marketing the service to consumers and transporting the appliances.⁴⁵ The cost of such programs also covers a more thorough recycling of the components of the appliance than would be required under the MDA.

* For example, the City of Sacramento will pick up and take away a household refrigerator for free on the annual household cleanup day. But it will charge \$35 per unit to take away more than one.

COMPLIANCE WITH SECTION 42175 OF THE MDA

There are likely widespread violations of the MDA Section 42175 requirement to remove and properly dispose of MRSH.

COMPLIANCE MONITORING BY THE CALIFORNIA INTEGRATED WASTE MANAGEMENT BOARD

The MDA required the California Integrated Waste Management Board (CIWMB) to produce a metallic discards management plan. The management plan was issued in 1993, shortly before the MDA Section 42175 provisions were to take effect.*

The CIWMB management plan concluded that “Existing laws and the current economic climate together provide generally adequate regulatory control and economic incentives such that special materials contained in major appliances and vehicles do not create a large problem in California.”⁴⁶

This is a little puzzling, because in preparation for drafting the management plan, CIWMB had contracted for a study of the issue that reached very different conclusions. The background study concluded that “controls or measures beyond those authorized by existing legislation on the handling and processing of appliances that contain PCB-containing capacitors and CFCs are necessary to protect human health and the environment a significant number of small generators (e.g., primarily households and businesses) and smaller appliance handling operations violate these requirements.”⁴⁷ It also noted that “CFC regulation does not control or prevent the release of CFCs during appliance collection and transportation; the stage of the discarded appliance management system where releases are most likely.”⁴⁸

The Management Plan itself noted that the removal of PCB-containing capacitors and ballasts from major appliances before appliances are crushed for transport or transferred to a baler or shredder “does not commonly occur.”⁴⁹

It is not clear why the CIWMB reached conclusions seemingly at odds with its own background study. It appears likely, however, that CIWMB was receiving conflicting advice from different stakeholders. A Metallic Discards Task Force was formed in 1993 to review the effectiveness of the MDA.[†] The task force found itself “strongly polarized” on the issue of removal of special materials from appliances and whether any additional programs or resources were necessary to ensure their removal from appliances.⁵⁰

* The law had Section 42175 taking effect in January 1994.

† The task force included representatives from DTSC, City of San Jose, State of California Automobile Dismantlers Association, California Air Resources Board (CARB), Butte County Air Pollution Control District (APCD), General Electric Company, American Automobile Manufacturer’s Association, California EPA, U.S. EPA Region 9, Sonoma County Solid Waste Management, Norcal Waste Systems, National Association of Retail Dealers of America, Steel Recycling Institute, Hugo Neu-Proler Company, Californians Against Waste, Pacific Gas & Electric, Sacramento Municipal Utility District, and the Association of Home Appliance Manufacturers and General Electric.

Shortly after MDA Section 42175 came into effect, CIWMB staff performed some “nonregulatory monitoring” to study compliance with the MDA. This included preparing case studies on recycling companies such as scrap yards, metal recyclers, and haulers. CIWMB staff also contacted enforcement staff at 26 counties.⁵¹

The case studies concluded that in urban areas, most metallic discards were being recycled for their metals, and that “methods have been developed to remove and properly dispose [of] special materials.” However, they observed that rural counties which were remote from recycling centers had more of a problem with illegal dumping of appliances. Some local enforcement agencies felt the costs imposed by the MDA, and associated higher disposal fees at landfills, were encouraging illegal dumping.⁵²

The case studies concluded that most facilities were complying with requirements to remove and dispose of CFCs and waste oil. However, “some special materials such as capacitors containing PCBs, mercury switches, and used oils are being removed by a contractor while others are not being removed because the processor was unaware of such materials.”⁵³ At some landfills, special materials such as capacitors and mercury switches were “not being removed prior to being sent to a metal salvaging company.”⁵⁴

COMPLIANCE MONITORING BY THE DEPARTMENT OF TOXIC SUBSTANCES CONTROL (DTSC)

Beginning in 1997, legislative changes clarified that enforcement of the parts of the MDA having to do with hazardous wastes rested more with DTSC than with the CIWMB. In both 1997 and in 2001-2002, DTSC, in cooperation with local agencies, carried out inspections of scrap yards and other facilities that recycled or dismantled appliances. I was able to obtain raw field inspection reports for 16 facilities that handled appliances. It was not clear from most of these reports how the facilities were chosen or what exactly the various inspectors were looking for. These inspections appear to have been more concerned with how hazardous wastes were handled than with verifying that all MRSH were being removed from appliances.

Based on my own review of the reports of these 16 site visits, it appears that in five cases, the inspector observed a violation of the requirement of the MDA to remove MRSH. Violations of other hazardous waste rules were noted at ten facilities. These mostly seemed procedural, such as lacking a hazardous waste generator identification number or improperly labeling containers of waste oil.

A more systematic evaluation of MDA Section 42175 compliance was carried out in 2003. I say more systematic because in this instance it was clear that the primary concern was to determine whether operators were removing the MRSH. In addition, it was clear that the same inspector was visiting all the facilities and looking for the same sorts of violations. The DTSC investigator visited nine facilities, including three small scrap metal yards, three landfills, and three specialized refrigerator recycling companies.⁵⁵

The inspector noted that small scrap metal yards violated their own policies by allowing refrigerators into their scrap piles with compressors still attached, the oil not drained, and capacitors and switches still on the units. These were mixed with other scrap metal, crushed, and sent on to larger recyclers. CFCs were usually removed if present.⁵⁶ The inspector also noted that when a small scrap yard rejects a unit, “there is nothing to prevent a homeowner from deliberately cutting out the compressor, returning it to the scrap metal yard, and collecting money for the scrap metal value.”

The situation was not much better at the landfills. They all hired contractors to remove the CFC's. At two of them, only the CFC's were removed. One of these sent units to a scrap metal yard where compressor oil was removed. But only one of the three landfills had all of the materials requiring special handling removed.

The investigator concluded that the only parties consistently removing PCB capacitors and mercury switches were the three specialized “third party” recycling companies, which are sometimes hired by landfills or other entities to help them recycle appliances and deal with associated regulated materials.

The investigator noted that large scrap metal shredding companies have a stated policy of not accepting contaminated materials from these suppliers. However, he concluded from the inspections of scrap yards and landfills that the scrap metal sent on to the shredders sometimes still contained these materials.

SITE VISITS DURING THIS RESEARCH

I visited several appliance recycling facilities while researching this report. One was a privately managed municipal waste transfer station. I observed that waste oils and CFCs were being recovered from refrigerators. While I did not directly observe any PCB capacitors or mercury-containing components being left in appliances, the operation did not appear to have any procedures for identifying them or removing them, so it seems likely that if any were present they would have remained when the appliances were sent to a metal shredder.

I also visited a large metal shredder. The company inspects incoming appliances for MRSH and requires suppliers to sign agreements stating that MRSH will be removed from appliances before delivery to the shredder. However, the managers stated that most appliances are crushed before they arrived, and thus it would be difficult to detect the presence of all MRSH.

I visited three companies that specialize in environmentally sound recycling of appliances. These generally work under contract to other entities such as landfills, appliance retailers, or utilities. These operations seemed for the most part well-equipped to properly remove and dispose of MRSH. However, even at one of these, it was not clear that staff would look for and remove mercury-containing components from older appliances. This operator told me there were no hazardous materials in washers and dryers. But other sources indicate some old washers contain mercury switches.⁵⁷ He also

told me that mercury-containing components are rare. Yet another company I visited showed me a 55-gallon drum filled with mercury components recently removed from appliances.

REASONS FOR NONCOMPLIANCE WITH SECTION 42175 OF THE MDA

There seem to be several reasons why there is widespread noncompliance with Section 42175 of the MDA:

- 1) Economic incentives for noncompliance,
- 2) Lack of clarity in the law about who must comply, what is required, and who is responsible for enforcement,
- 3) The challenge of enforcing the law when there is such a large number and variety of parties who may potentially be in violation, and
- 4) Level of enforcement effort.

Economic Incentives for Noncompliance

In 1993, a CIWMB study noted that “The costs to generators for proper management of the special materials appear to lead to some illegal processing” of appliances.⁵⁸

In addition to the normal costs of operating a business, those dealing with MRSH in accordance with state laws and regulations will have additional costs. Some examples:

- Labeling and manifesting requirements,
- Capability for spill response and emergency response,
- Waste storage and handling, and reporting,
- Specialized equipment (such as CFC recovery equipment),
- Permits and licenses, and
- Fees for shipping, disposing of, or recycling wastes.

While appliances contain materials that are cost-effective to recover (scrap metal and sometimes CFCs), overall the cost of recycling appliances in compliance with the law is greater than the value of these materials. That is why recyclers and landfills generally charge a fee to recycle, and why companies that recycle for large entities such as utilities or retail chains must be paid to do so. If, however, one does not dispose of the MRSH properly, the cost of recycling is probably reduced and the profitability greater.

There are two basic ways in which the MDA can be violated to save costs. One is to leave the MRSH in the appliance and hope that it won't be noticed when the appliance is sold for scrap. This kind of violation seems most likely to occur with respect to mercury switches/thermostats and PCB capacitors. It is not easy to tell from a casual inspection

whether these materials are present in a given appliance. They are mostly found in older appliances, but not in every one of them.

The final purchaser of scrap appliances, the metal shredder, generally enforces a policy of not accepting appliances containing MRSH from their suppliers. They have employees inspect the incoming loads. However, they are less likely to notice if this policy has been violated by the presence of a small item like a capacitor or switch, particularly if the appliances arrive in a crushed or baled form.

Violations of the MDA with respect to CFCs and oils are likely to take a different form. Suppose, for example, one wants to sell a refrigerator as scrap. It will be difficult to sell the appliance if it is completely intact. The shredder, and likely others in the scrap industry, are likely to notice the presence of an intact motor (which contains used oil) and intact refrigerant lines (containing CFCs). However, it is quite easy to dispose of the offending items. If one has the right equipment, the CFCs are valuable enough to recover them, but if one does not want to go to the trouble and expense, it is simple enough to cut the lines and let it escape. It is also easy to cut out the compressor motor and drain out the oil. It seems likely there are appliance owners or businesses (haulers, scavengers, scrap yards, recyclers) who simply throw away these MRSH, especially if they deal with small volumes and it is not economically rewarding for them to invest in the necessary equipment, permits, and so forth to dispose of them properly.

Lack of Clarity in the Law

Section 42175 of the MDA requires MRSH to be removed from recycled appliances. As originally enacted in 1991, the law left it unclear which state agency was responsible for enforcement of this section, CIWMB or DTSC. CIWMB regulates many of the waste disposal sites that collect and recycle appliances. However, it is DTSC, not CIWMB, that is responsible for hazardous waste enforcement.

However, DTSC's authority was not clear-cut either, since MRSH inside appliances are not normally considered hazardous waste. In 1997, the law was amended to clarify that once hazardous materials were removed from appliances, they should be regulated as hazardous wastes (AB 847, Wayne).

This left, however, the question of who was responsible for seeing to it that the MRSH were removed in the first place. SB 633 (Sher, 2001) added Section 42175.1(c), specifying that a failure to remove the MRSH (as required by Section 42175) was a violation of the California Health and Safety Code, and thus under the jurisdiction of the DTSC. In most localities, that authority is delegated to a local enforcement agency, known as a (CUPA).

Nevertheless, there are still uncertainties about enforcement of Section 42175. When we surveyed CUPAs about appliance recycling, we asked them if they kept track of who recycled appliances in their jurisdiction and whether they enforced the rules requiring removal of MRSH. In many cases, CUPAs indicated they didn't keep track of recyclers

or the MRSH removal requirements unless a given company fell under their authority as a hazardous waste generator. The problem with this approach is that if a company is failing to remove the MRSH, or is failing to report that it does so, it will probably not be registered as a hazardous waste generator in the first place, and will thus be flying under the radar. In order to properly enforce the MDA, CUPAs would need to aggressively identify which companies are handling appliances for recycling and inspect them to ascertain whether they are complying with the MDA, regardless of whether they are already known to be a hazardous waste generator. I will discuss the results of the survey in more detail later.

Other ambiguities remain in the language of the MDA. Section 42175 of the MDA requires that MRSH “shall be removed from major appliances and vehicles in which they are contained prior to crushing for transport or transferring to a baler or shredder for recycling.” However, the law does not specify exactly who is responsible for doing this, or when. A discarded appliance could evidently pass through many hands, and undergo various degrees of dismantlement and processing, without necessarily triggering this requirement.

There is no system in place to license or certify who is considered capable of and/or responsible for removing MRSH. This makes it more difficult to enforce the Act. At each point in the recycling chain, a party can say they thought it was the responsibility of someone else to remove the MRSH. Since there is no requirement that removers of MRSH be licensed or certified, such claims are easier to make and harder to verify.

The one exception to this is the removal of CFCs. As noted earlier, anyone who removes CFCs from an appliance must be registered with the U.S. EPA, and show that they have the proper equipment and training. Whoever takes the final step in disposal of an appliance must obtain verification that the refrigerants have been removed. Violators may face heavy penalties. It appears that CFCs are the most likely of any of the MRSH to be properly removed and handled. While this is no doubt due in part to the economic value of CFCs, the federal enforcement and the clearer rules and accountability for their removal may also play a part.

Shredders generally require that their suppliers sign agreements to remove the MRSH before delivering them appliances, which they say passes the responsibility back upstream to the party that is supplying the appliances. Many of those parties (landfills, scrap yards, etc.) in turn claim to impose similar requirements on *their* suppliers, and so on.

CIWMB reported in 1995 that 50 percent of county recycling coordinators answering a survey were not aware of MDA mandates.⁵⁹ While a comparable current figure is not available, it seems probable that some facilities that handle appliances are simply not fully aware of the MDA requirements.

In addition to the lack of clarity over *who* must remove MRSH, the MDA is unclear as to *when* MRSH must be removed. Section 42175 says MRSH must be removed “prior to

crushing for transport or transferring to a baler or shredder for recycling.” This sentence is confusing and ambiguous. It also fails to take into account the realities of how appliances are processed.

The key should be to ensure the removal of the MRSH prior to the activities that are likely to release the harmful substances or that will hinder their proper removal.

This means that the law should require MRSH to be removed before an appliance is shredded. It should require MRSH to be removed before the appliance is crushed – crushing could release the MRSH, and make it impossible to remove any MRSH still encased in the crushed appliance.

Furthermore, some appliances are cut apart or sheared with large saws prior to being baled or transported (baling means packaging the pieces in bundles). Anyone intending to properly deal with the MRSH would remove the MRSH before the appliance or its metal casing is sawed or sheared apart, and before the appliance is baled.

The law should also state that the MRSH must be removed if the appliance is being dismantled. Some care will be needed in the definition of dismantlement. For example a distinction should be made between dismantlement for recycling and dismantlement for repair or servicing of an appliance.

Putting too much emphasis on transport and transferring, as the current law does, will create confusion. There are too many variations in when these different actions might occur. For instance, some recyclers dismantle the appliances, cut them up and bale them before shipping them off to a shredder. Others ship the appliances more or less whole to the shredder.

The current language is creating confusion and odd interpretations. I found in interviews and documents that some within DTSC interpret the current language to mean that a recycler could partially dismantle an appliance, and then send it on to a shredder, without having violated Section 42175 of the MDA.

For example, when DTSC inspected several recycling facilities in 1997, inspectors found some cases where the recyclers probably left some of the MRSH in the appliances or vehicles. This would presumably violate Section 42175 of the MDA. However, some DTSC staff evidently found Section 42175 to be ambiguous as to whether the inspected recyclers were obligated to remove the MRSH if they were not about to crush or shred the appliance themselves. A staff memo stated that Section 42175 “can be reasonably interpreted to mean that the facility that intends to crush or shred the appliance must remove these materials, which may be hazardous wastes, prior to crushing or shredding the appliances. Under this interpretation many of the violations perceived [in the inspections] would not be violations at all.”⁶⁰

The Large Number and Variety of Parties Who May be in Violation

As we have seen, an appliance passes through many hands as it goes through the recycling process, beginning with the millions of California households that dispose of appliances. A regulatory agency trying to assure that the MRSH are properly removed and disposed of would in theory have to regulate all of these parties in the recycling chain.

Level of Enforcement Effort

At present, it does not appear that DTSC is devoting resources directly to enforcing Section 42175 of the MDA. That is, DTSC is not conducting inspections or otherwise keeping track of what the facilities and companies that recycle appliances are doing. This is largely because it is viewed as a matter for enforcement by local CUPAs – that is, local (city and county) programs that enforce hazardous waste generator laws.* DTSC has never issued an enforcement order or taken other formal action against a party for violation of Section 42175 of the MDA.⁶¹

In order to get a better sense of whether and how CUPAs are enforcing the MDA, we conducted a simple survey of CUPA agencies by telephone and e-mail. There are 80 CUPAs in the state enforcing the hazardous waste rules. The survey received responses from 54 city and county CUPAs.

The survey indicates that most CUPAs are trying to enforce the MDA. However, the results also strongly suggest that there are many companies or facilities throughout the state that process appliances, but are not being inspected or otherwise falling under regulatory scrutiny. The survey also found that even where the MDA is being actively enforced, it is not being enforced uniformly with respect to all the regulated MRSH.

Some highlights from the survey response:

- 1) Of the agencies responding, 54 percent (29 out of 54) said that within their area of jurisdiction were companies or facilities that dismantle, crush, or otherwise process appliances for recycling. Seven percent (four out of 54) did not know whether they had such operations within their jurisdiction.
- 2) Among the agencies that reported having appliance recycling facilities in their jurisdiction, 83 percent said they attempted to keep track of these operations (their name, location, etc.). However, only 30 percent said they kept track of *all* these operations. Seventy percent said they only kept track of some or most of them. As noted earlier, many CUPAs only keep track of these facilities if they are already known to be hazardous waste generators – in other words, if the company is handling appliances but hasn't registered as a hazardous waste generator, the CUPA may not be aware of them or inspecting them.

* Most parts of the state are under the jurisdiction of a CUPA hazardous waste program. The exceptions are Butte, Sutter, Imperial, and Trinity Counties.

- 3) Seventy-nine percent of the jurisdictions with recycling facilities said they made some effort to verify the removal of MRSH from appliances at the facilities they knew about. Twenty-one percent said they did not. Twenty-seven percent said they verified MRSH removal at *every* facility they knew about. Seventy-three percent said they had verified MRSH removal only at some or most of these facilities or companies.
- 4) Of the respondents who said they verify MRSH removal, 91 percent said they did so through on-site inspections.
- 5) The respondents who said they verify MRSH removal were asked which materials they verified the removal of. They responded as follows:

**Table 3: Respondents Who Verify MRSH Removal;
Which Materials They Verify For**

Oil	83%
CFCs	87%
Mercury	78%
PCBs	39%

As the above table indicates, most respondents who do verify the removal of MRSH (a total of 23 respondents) look for removal of oil, CFCs, and mercury. Fewer look for PCB capacitors.

However, percentages who check for specific kinds of MRSH are lower when calculated for the group of *all* CUPAs who said they have appliance recycling or processing operations within their jurisdiction (29 respondents).

**Table 4: Percentages Verifying MRSH Removal, Out of All Respondents With
Recycling Facilities or Companies In Their Jurisdiction**

Oil	66%
CFCs	69%
Mercury	62%
PCBs	31%

That is, of the 29 CUPAs reporting that they have appliance recycling operations in their area of jurisdiction, about two-thirds are checking to see if waste oil, CFCs, and mercury are being removed and about a third are checking for PCB capacitors.

In addition, many of those that inspect are only inspecting for some of the MRSH listed in the MDA. Few reported checking for all four of the MRSH listed above. Out of the 29 CUPAs reporting that they have appliance recycling operations in their area of jurisdiction, only seven (25 percent) reported that they verify the removal of all four kinds of MRSH.

ENVIRONMENTAL IMPLICATIONS OF NONCOMPLIANCE

I will first review the nature and potential hazards of the MRSH. Then I will discuss what little is known about their environmental release from appliance recycling.

ENVIRONMENTAL EFFECTS OF CFCs

CFCs are not hazardous in the usual sense of being toxic, corrosive, etc. They cause depletion of the earth's stratospheric ozone layer. The ozone layer filters a band of ultraviolet solar radiation known as UVB. Ozone depletion increases the amount of UVB radiation reaching the earth's surface. This in turn may increase the incidence of human skin cancer and cataracts, and may also harm ecosystems by impairing the growth of terrestrial plants and marine phytoplankton.

According to an estimate given to me by a large recycler, a typical refrigerator using CFCs contains about six ounces of the refrigerant. According to an estimate published in 1993, releases of CFCs from discarded appliances and vehicles throughout the United States amounted to one percent of total annual CFC releases in the U.S.⁶² Total U.S. emissions of CFCs were estimated at 47,000 metric tons in 1997.⁶³ Overall emissions of CFCs and other ozone-depleting gases are will continue to diminish under the phased reductions and caps of the Montreal Protocol.

ENVIRONMENTAL EFFECTS OF USED OIL

Mineral (petroleum-derived) oils, including used engine oil, are listed as carcinogens by the State of California.⁶⁴ Oils contain polycyclic aromatic hydrocarbons (PAHs), some of which can be carcinogenic.⁶⁵ Clearly there are many sources of used oil, including both appliances and automobiles.

According to the CIWMB, average sales of industrial oil* in California were about 140 million gallons per year from 1994-2002. Over that same period, an average of about 18 million gallons were recycled.⁶⁶ I do not have data on the amount of oil disposed of annually, but given the large disparity between the amount sold and the amount recycled, it seems reasonable to surmise that millions of gallons, perhaps tens of millions of gallons, are being either lost during use or improperly disposed of – on land, in storm drains, waterways, the trash, etc.

ENVIRONMENTAL EFFECTS OF MERCURY

Mercury is a naturally occurring metal that is liquid in its metallic form. When present in soil or water, it may be taken up by microscopic organisms and converted to methyl

* Industrial oil includes, but is not limited to, compressor, turbine, or bearing oil, hydraulic oil, metalworking oil, or refrigeration oil. CIWMB distinguishes it from "lubricating oil," which is the oil found in internal combustion engines in cars, trucks, and heavy machinery.

mercury, in which form it can bioaccumulate in the food chain (which is why eating fish from contaminated waters can be hazardous).⁶⁷

Mercury is listed by the State of California as causing reproductive disorders. Methyl mercury is listed as carcinogenic.⁶⁸ Methyl mercury and metallic mercury can cause brain and kidney damage.⁶⁹

Consumption of mercury by humans can lead to developmental problems in fetuses and young children.⁷⁰ Harmful effects on fetuses can include brain damage, retardation, blindness, and other disabilities. Children exposed to mercury may develop problems of the nervous and digestive systems.⁷¹

It should be noted that appliance switches and thermostats are one among many contributors to overall environmental mercury. Total emissions of mercury in California from all sources were an estimated 49,752 pounds in 2001.⁷² According to DTSC, a mercury switch contains about 3.5 grams of mercury (about an eighth of an ounce).⁷³ An estimate given to me by the recycler Appliance Recycling Centers of America (ARCA) was higher – about a quarter to half an ounce per switch.

In 1994-1995, approximately 87 percent of the nation's atmospheric mercury emissions originated from combustion point sources, including fossil fuel combustion, which emitted 84 tons into the air in 1996, and waste combustion and incineration.⁷⁴ In California, mercury air emissions from waste management, including landfills and combustion, were 2.24 tons in 2000, with 370 pounds associated with broken fluorescent tubes. Much of California's aquatic mercury originates from the waste of old gold and mercury mines. Each year, an estimated 118 pounds of mercury from dental offices enters the state's water through sewage.⁷⁵ Mercury-containing wastes disposed in landfills include fluorescent lamps, soils, industrial wastes, ashes, and sewage treatment sludges.⁷⁶

ENVIRONMENTAL EFFECTS OF PCBs

PCBs are listed by the State of California as a class of chemicals known to cause cancers and reproductive abnormalities.⁷⁷

Polychlorinated Biphenyls (PCBs) are toxic, carcinogenic, and are persistent in the environment. They can cause reproductive and developmental defects. They have been noted in water, sediments, wildlife, and throughout the food chain including human tissue and milk. They can enter the body through the lungs, digestive tract, and skin, and are stored in fatty tissue.⁷⁸ PCBs do not readily break down, and thus may persist a long time. They tend to bind to soil and aquatic sediments, but may travel a great distance when released in the air.⁷⁹

From 1929-1977, Monsanto Company, the sole manufacturer of PCBs in the United States, produced 700,000 tons of PCBs. PCBs were widely used in electrical equipment,

particularly transformers, capacitors, and fluorescent lamp ballasts. Annual PCB sales peaked at 85 million pounds in 1970.⁸⁰

The manufacture of PCB capacitors was banned in the U.S. in 1978, but stockpiled PCB capacitors continued to be used for a period of time after 1978. Some appliances manufactured abroad may also have PCB capacitors despite the federal restrictions.⁸¹

For the most part, PCBs are no longer in use in the U.S., although they are still released into the environment from items that contain them, as well as from inadvertent generation during certain production processes, and from storage and disposal facilities.⁸² In 2001, an estimated 28,000 pounds of PCBs were released into the environment in California.⁸³

According to an EPA estimate cited in 1998 by an appliance recycling industry organization, less than five percent of recycled white goods contain PCB capacitors, and the numbers are likely diminishing over time.⁸⁴ PCB capacitors are most likely to be found in pre-1979 room and central air conditioners, microwave ovens, furnaces, and light ballasts, as well as in some refrigerators and freezers.⁸⁵ A PCB ballast capacitor may contain about one ounce of PCB dielectric fluid.⁸⁶

ENVIRONMENTAL RELEASES OF MRSH FROM APPLIANCES

Environmental release of MRSH from appliances is difficult to quantify. There are likely numerous small discharges occurring in many places that may be individually small but could be cumulatively significant. Releases may be larger where large numbers of appliances are dismantled or shredded.

There are two basic ways MRSH might get into the environment. First, some individuals and companies probably remove or release MRSH, either intentionally or unintentionally, without properly handling and disposing of them. Since CFCs are a pressurized gas, they in particular are probably prone to accidental release.

In addition, MRSH may also be left in the appliances when the appliances are disposed of. If the appliance is deposited into a landfill, the MRSH may be released when the appliance is subsequently crushed or damaged. The MRSH might then leach out of the landfill. This is less likely in a lined landfill, but most of California's landfills are not lined.^{87*}

If the appliance is shredded, the MRSH will likely end up either being released as air emissions, or else it will end up mixed with the scrap metal and shredder waste ("fluff").

Shredder waste is often used as landfill cover (after being chemically treated to prevent the leaching of heavy metals).

* Of California's 224 landfills, 16 are fully lined, 138 are fully unlined, and the rest are partially lined.

There is no data available to quantify the amounts of MRSH entering the environment through these routes. It is possible to make estimates of the numbers of different kinds of appliances being disposed of. However, it is not known how widespread the violations of the MDA are that would lead to the release of MRSH.

There is some indirect evidence of the effects MRSH from appliances may be having on the environment. One of the state's largest metal shredding companies, the Adams Steel facility,* has attracted attention since 1988, when authorities determined that shredder waste there contained toxic heavy metals and PCBs. It was listed as a State Superfund site in 1991. Eventually, 58,550 tons of PCB-contaminated shredder waste and soil was removed in a cleanup that was completed in 1999.⁸⁸ State regulators believe that recycled appliances were a major source of the PCBs.⁸⁹

It should be kept in mind that the Adams Steel contamination developed before the MDA came into effect. A DTSC official who is studying shredder waste told me he believes the MDA has played a significant role in controlling PCB contamination at shredders. He noted that in the past shredders have had to carefully limit the amount of appliances they could shred because they noted spikes in their waste PCB levels when they shredded too many appliances. In the last several years, however, the problem appears to have diminished, and the amounts of appliances shredded has been able to increase without the levels of contamination found at Adams Steel in 1988. He attributed this trend to the influence of the MDA in encouraging the removal of PCB capacitors from appliances.⁹⁰

This does not mean that PCB contamination of shredder wastes has ceased to be an issue, however. Currently, two smaller shredders in southern California that only shred appliances (not automobiles) have come under investigation by DTSC because of suspected PCB contamination problems.⁹¹ The state's larger shredders are paving their sites with concrete to reduce soil contamination.⁹²

Some of the metals in shredder waste are regulated under hazardous waste laws, but are not included as MRSH in the MDA. These metals include cadmium, chromium, copper, zinc, and lead. Lead may come from auto batteries or residues from leaded gasoline. The other metals are suspected to come at least in part from the pigments in paints on cars and appliances.

In 1986, shredder waste was granted a nonhazardous designation by the state on the condition that it be treated with a chemical fixation process that fixes toxic soluble metals such as cadmium, chromium, lead, copper.

DTSC is currently re-evaluating its policies on shredder waste, including the current hazardous waste exemption. This includes an ongoing study to sample wastes at the state's largest shredding operations for levels of certain toxic materials. So far, the sampling has found treated wastes that exceeded state regulatory thresholds for lead, zinc,

* Previously known as Adams International Metals Corp. and Orange County Steel Salvage.

and cadmium. Such wastes would qualify to be designated as hazardous were it not for the treated waste exemption.⁹³

Results from this sampling study have so far found PCBs in all samples, but only two samples exceeded the regulatory thresholds.⁹⁴ Mercury was also detected, but at levels below regulatory thresholds.⁹⁵

In addition to the shredder wastes, PCBs or mercury from shredded appliances could go into the air or into the scrap metal. There is some evidence for the latter. The Ohio Environmental Protection Agency recently took enforcement action at a smelting mill where they found elevated air emissions of mercury. It is believed the mercury came from shredded scrap metal fed into the mill.⁹⁶

DTSC estimates that in 2001, 0.4 tons of mercury in shredder fluff was disposed in landfills.⁹⁷ However, it should be noted that much of the mercury that goes into shredder waste or into the shredded scrap metal probably comes from cars rather than appliances. Mercury switches are often found in cars, usually in trunk or hood light switches.

It should be noted that the rate of environmental release of some MRSH from appliances (in particular, mercury and PCBs) is likely to eventually diminish over time. These components are generally found only in older appliances. Over time there will probably be fewer and fewer such appliances in service or entering the waste stream.

POLICY OPTIONS TO ADDRESS NONCOMPLIANCE

The Director of DTSC recently stated that “DTSC may be considering enforcement strategies for the Metallic Discards Act. DTSC will be discussing enforcement priorities and strategies in the near future and has not yet determined the resources needed to enforce” Section 42175 of the MDA.⁹⁸

While DTSC may be developing options of its own, the information and issues raised in this report support a number of options and recommendations.

A. FEE-BASED RECYCLING AND INCENTIVES

There is currently little if any economic incentive to remove MRSH other than CFCs. And given the diffuse nature of the appliance recycling system, it is difficult to ensure compliance through enforcement alone. An alternative might be to create a system that rewards the removal of other MRSH. The study done by consultants for the Metallic Discards Task Force in 1993 stated that “Some form of financing and/or responsible entity program (i.e., manufacturer responsibility) may be necessary to subsidize appliance handling and processing costs.”⁹⁹

One possibility would be to provide payments to recycling programs or offer a bounty for recovered MRSH such as mercury switches or capacitors. This could be funded by the general public or by a fee imposed on manufacturers, dealers or purchasers of appliances. This would be somewhat analogous to the recycling deposit paid on some bottled beverages. Perhaps a closer analogy would be with the recently-enacted “e-waste” bill requiring the manufacturers of electronic devices to collect an electronic waste recycling fee from the consumer. The fee goes into a fund that finances payments to authorized electronic waste collectors and recyclers.¹⁰⁰

Also analogous is the state’s recycling system for used lubricating oil (the type of oil found in the engines of internal combustion engines). Under the California Oil Recycling Enhancement Act, manufacturers must pay \$0.16 to CIWMB for each gallon of lubricating oil sold in California. Registered industrial generators, curbside collection programs, and certified collection centers are eligible to receive \$0.16 for each gallon of used lubricating oil recycled.¹⁰¹

This sort of approach – sometimes termed an Advance Disposal Fee – was considered during the drafting of the original MDA, but never put into the language of the Act. One major obstacle would be determining who should pay, and how much. The mercury and PCBs are for the most part only in older appliances. Manufacturers and consumers might object to paying a fee to pay for disposal of materials that are not present in the appliances currently being sold.

A number of variants on this approach were considered in preparing the CIWMB’s 1993 Metallic Discards Management Plan (although none were ultimately recommended by the Board). It was noted that fees paid by manufacturers could be used to fund a privately

managed discarded appliance management system. Another possibility raised was using such fees to fund municipal recycling programs.¹⁰²

B. OUTREACH AND EDUCATION EFFORTS

A 2001 amendment to the Health and Safety Code makes it clear that DTSC or local officials must incorporate enforcement of Section 42175 into their hazardous waste inspection and enforcement programs.¹⁰³ But it may be necessary to clarify how CUPAs are supposed to carry out this responsibility. It might be helpful to issue guidelines on identifying which facilities are likely to remove MRSH from appliances, and a checklist for inspecting them (such as what sorts of equipment, records, and procedures to look for).

Updated technical guidance may also be needed regarding the proper methods used by recyclers to find and remove MRSH from appliances. CIWMB published an *Appliance Recycling Guide* in 1998, and this has in the past been mailed out to a list of potential appliance recyclers compiled by DTSC. It may be time to update the recycling guide and update the list of recyclers to send it to (such a list could also be useful to local enforcement agencies).

C. PERMITTING AND ACCOUNTABILITY

Under the current system, it is difficult to keep track of all the parties who might remove MRSH, and each party can always point the finger at someone else when asked whether they remove MRSH. The task of enforcement might be simplified if there were a requirement that any person who handles or removes special materials obtain a permit from a state agency. Anyone who crushes or shreds an appliance could be required to only accept appliances from someone who could certify the removal of MRSH by a licensed party.

D. HEIGHTENED ENFORCEMENT ALONE MIGHT JUST SHIFT THE PROBLEMS

When the CIWMB surveyed local agencies about appliance recycling in 1993, it reported that “Several survey respondents...expect illegal dumping to be a problem, especially in rural areas, if compliance costs are too high.”¹⁰⁴ It is often noted that increasing the compliance costs will simply lead to more illegal dumping, or more appliances going into landfills without being recycled.

This view has some inherent plausibility – the appliance recycling system has many varied participants and the economics of recycling seem marginal enough that if you increase costs at one point in the system, the problem is likely to move to another, rather like squeezing a balloon. For example, if you try to crack down on shredders who may be accepting appliances that still contain MRSH, this might reduce the profitability of shredding appliances. This in turn might reduce the price they pay for appliances, or lead them to reject appliances from certain suppliers. The result of that could be higher

charges when a household wants to leave an appliance with MRSH at a landfill, which in turn could encourage illegal dumping of appliances or the MRSH.

Any proposal to significantly change the rules on appliance recycling that could raise compliance costs should probably be supported by an analysis that assesses the likelihood of unintended consequences. Avoiding such unintended consequences may require measures beyond more aggressive enforcement of the existing rules. Possible measures to achieve this have already been noted – such as tightening the rules to more clearly define accountability, and changing the economic incentives.

E. CLARIFICATION OF THE METALLIC DISCARDS ACT

There are several areas where the MDA could be made clearer.

Clarifying When Section 42175 Comes Into Play

As noted earlier, the MDA language is ambiguous as to *when* the Section 42175 requirement comes into effect. The current language says that materials requiring special handling must be removed from major appliances and vehicles “prior to crushing for transport or transferring to a baler or shredder for recycling.” This language should be changed to make it clearer. In order to ensure that MRSH are not released into the environment, the law should clearly state that they should be removed before an appliance is crushed, baled, sawed or sheared apart; and that they should be removed when an appliance is dismantled for recycling or disposal.

Making the Law Uniform With Respect to Appliances and Vehicles

The MDA applies to both vehicles and appliances, but treats them differently. For example, the MDA definition of MRSH includes mercury switches found in appliances, but not those found in vehicles. There is a requirement in regulation that mercury switches in vehicles about to be shredded must be treated as hazardous wastes beginning in 2005.¹⁰⁵ This is not the only discrepancy between appliances and vehicles in the MDA. There is no obvious policy reason why hazardous wastes in recycled vehicles should be treated differently from the same wastes in appliances.

F. REVISIT THE DEFINITION OF MRSH

The definition of MRSH includes encapsulated PCBs in major appliances. Only a small percentage of older appliances have capacitors that contain PCBs, and it is not easy to be sure whether a given capacitor does or does not. Those recyclers who do try to remove PCB capacitors generally seem to operate under the rule that all metal-encased capacitors are suspect and should be treated *as if* they contain PCBs.

Accordingly, it might make sense to include a broader, more generic class of capacitors that should be removed. According to some sources I reviewed, only metal-encased capacitors are likely to contain PCBs. Thus, compliance would be simplified if the

requirement were to remove metal-encased capacitors rather than PCB-containing capacitors.

There may be an environmental benefit to this as well. Some capacitors that do not contain PCBs may contain other toxic substances. For instance, the capacitors used in fluorescent light ballasts and other equipment probably contain Di(2-Ethylhexyl)phthalate, also known as DEHP. DEHP was substituted for PCBs when the use of PCBs was banned in 1979. Gradually, ballast makers began to replace DEHP capacitors with other kinds, but the use of DEHP in ballasts continued, in some cases until the early 1990s.¹⁰⁶ DEHP is listed as a carcinogen on California's "Proposition 65 list."¹⁰⁷ In animals, high levels of DEHP have been found to damage the liver and kidney and affect the ability to reproduce.¹⁰⁸

G. CONSIDER EXTENDING REFRIGERATOR RECYCLING PROGRAMS

Utilities (funded by their ratepayers) are currently sponsoring ambitious programs that safely recycle thousands of old refrigerators and freezers. These programs can be a cost-effective way to reduce the demand for electricity.¹⁰⁹ They are also a good way to ensure that many old refrigerators are recycled properly. The programs sponsored by the three publicly-owned utilities in California currently cover most, but not all California households. The state might want to explore ways to extend this type of service to all households. However, it should be kept in mind that these programs are limited to the trade in of working refrigerators and freezers, and cannot address the majority of refrigerators and freezers that are disposed of.

H. DOCUMENTING THE EXTENT OF THE ENVIRONMENTAL IMPACTS

There is strong circumstantial and anecdotal evidence to infer that failure to comply with the MDA is causing harm to the environment. Millions of appliances are being disposed of. Compliance with and enforcement of the MDA Section 42175 is often spotty. Therefore, MRSH are probably being illegally dumped and shredded. The likely result is release of mercury, PCBs, used oil, and CFCs.

However, we do not know how much contamination occurs. Of the appliances disposed of, it is not known with any precision how many of them contain PCBs or mercury switches/thermostats. The extent of violations of the MDA are not known. Nor did I find much information on the fate of MRSH that are not properly removed.

Until such questions are answered, the benefits of achieving better compliance with Section 42175 of the MDA will be difficult to quantify.

Further research could possibly yield more information on this subject. Estimates of the numbers of various kinds of appliances discarded are already available. It may be possible to get estimates from recyclers about the frequency with which various kinds of MRSH are found in different sorts of appliances. From this, we could estimate the total amounts of MRSH discarded in appliances in a year.

Those appliance recyclers who are complying with the law on MRSH will have hazardous waste generator identification numbers and will produce manifests indicating how much hazardous waste they are disposing of. It might be possible to develop a list of the state's licensed recyclers and compile from these manifests an estimate of how much hazardous waste they are legally disposing of each year. We could then compare that to the amount of hazardous waste we think is in the discarded appliances and get a sense of how much hazardous waste is unaccounted for through the properly regulated disposal methods.

Such estimates might have to cover both vehicles and appliances, rather than just appliances, since there are scrap yards and other facilities that handle both, and they would not likely distinguish between wastes (such as oil and mercury switches) that come from appliances and wastes that come from vehicles.

GLOSSARY OF ABBREVIATIONS

CFCs	Chlorofluorocarbons (refrigerant – often found in refrigerators and freezers)
CIWMB	California Integrated Waste Management Board
CUPA	Certified Unified Program Agency (local enforcement agency)
DTSC	California Department of Toxic Substances Control
EPA	Environmental Protection Agency
HCFCs	Hydrofluorocarbons (refrigerant – often found in air conditioners)
HFCs	Type of hydrofluorocarbon that doesn't deplete ozone layer (used in newer appliances)
MDA	Metallic Discards Act (Public Resources Code Sections 42160-42176)
MRSH	Materials Requiring Special Handling
PCBs	Polychlorinated Biphenyls

ENDNOTES

- ¹ California Public Resources Code Section 42161.
- ² California Public Resources Code Section 42170.
- ³ California Public Resources Code Section 42175.
- ⁴ California Public Resources Code Section 42167.
- ⁵ Department of Toxic Substances Control, "Hazardous Waste Generator Requirements," California Environmental Protection Agency Fact Sheet, January 2002.
- ⁶ Appliance Recycling Information Center, "Recycling Major Home Appliances," INFOBulletin #1, <http://www.aham.org/aric/aric.cfm>.
- ⁷ California Integrated Waste Management Board, *Appliance Recycling Guide*, California Environmental Protection Agency, Publication #500-94-022, 1998, 4.
- ⁸ California Integrated Waste Management Board, *Appliance Recycling Guide*, 4.
- ⁹ California Integrated Waste Management Board, *Metallic Discards Management Plan*, August 1993, 2-3.
- ¹⁰ Association of Home Appliance Manufacturers, "Restoring Nature's Balance: Refrigerant Recovery Training Manual," (Chicago, IL: AHAM, 1994), 17-18.
- ¹¹ California Integrated Waste Management Board, *Metallic Discards Management Plan*, 2.
- ¹² Code of Federal Regulations, 40 CFR Section 82.156(f).
- ¹³ Agency for Toxic Substances and Disease Registry, "Polychlorinated Biphenyls," February 2001, <http://www.atsdr.cdc.gov/toxfaq.html>.
- ¹⁴ Appliance Recycling Information Center (ARIC), "Major Appliances and PCB Small Capacitors," INFOBulletin #5, Washington, D.C., undated.
- ¹⁵ California Integrated Waste Management Board, *Appliance Recycling Guide*, 10.
- ¹⁶ Appliance Recycling Information Center (ARIC), "Major Appliances and PCB Small Capacitors," INFOBulletin #5, Washington, D.C., undated.
- ¹⁷ California Integrated Waste Management Board, *Metallic Discards Management Plan*, 5.
- ¹⁸ California Integrated Waste Management Board, *Metallic Discards Management Plan*, 15.
- ¹⁹ California Department of Toxic Substances Control, "Used Oil and Oil Filter Management," Fact Sheet, April 2003, http://www.dtsc.ca.gov/PublicationsForms/OAD_Used-Oil_FS.pdf.
- ²⁰ California Department of Toxic Substances Control, "Used Oil and Oil Filter Management."
- ²¹ Appliance Recycling Information Center (ARIC), "Mercury in Home Appliances," INFOBulletin #8, Washington, D.C., August 1998.
- ²² Grassroots Recycling Network, "Mercury in Vehicles: A Sensible Solution to a Serious Problem," <http://www.grn.org/assets/pdfs/hg/MercuryInVehicles.pdf>.
- ²³ SB 633 (Sher, 2001).
- ²⁴ Department of Toxic Substances Control, "Managing Universal Waste in California," California Environmental Protection Agency Fact Sheet, June 2003, http://www.dtsc.ca.gov/PublicationsForms/HWM_FS_UWR.pdf.
- ²⁵ Department of Toxic Substances Control, "Managing Universal Waste in California."
- ²⁶ Department of Toxic Substances Control, "Managing Universal Waste in California."

-
- ²⁷ California Code of Regulations, Title 22, Division 4.5, Chapter 23, “Standards for Universal Waste Management.”
- ²⁸ California Code of Regulations, Title 22, Division 4.5, Chapter 11, Section 66261.50.
- ²⁹ Based on estimates provided by Glynnis Jones, industry consultant and former vice president of Appliance Recycling Centers of America, Inc. (ARCA), March 2004, by e-mail.
- ³⁰ California Integrated Waste Management Board, *Appliance Recycling Guide*, California Environmental Protection Agency, June 1998, 1.
- ³¹ California Integrated Waste Management Board, *Statewide Waste Characterization Study: Results and Final Report*, December 1999, ES-5.
- ³² Estimates provided by Glynnis Jones (*op cit*) of numbers of appliances disposed of in California and average weights of different types of appliances.
- ³³ Steel Recycling Institute, “Fridge Today, Car Tomorrow: Appliance Recycling Efforts Supplying Steel for Future Products,” www.recycle-steel.org/pub/appliance/main.html; Steel Recycling Institute, “A Few Facts About Steel – North America’s #1 Recycled Material,” www.recycle-steel.org/fact/main.html.
- ³⁴ California Integrated Waste Management Board, *Appliance Recycling Guide*, 8.
- ³⁵ California Integrated Waste Management Board, *Appliance Recycling Guide*, 13, 18.
- ³⁶ California Integrated Waste Management Board, *Appliance Recycling Guide*, 16.
- ³⁷ California Department of Toxic Substances Control, *Draft Report: California’s Automobile Shredder Waste Initiative*, 14.
- ³⁸ California Department of Toxic Substances Control, *Draft Report: California’s Automobile Shredder Waste Initiative*, 14, 15-16.
- ³⁹ Phil Sission, Sission & Associates, preliminary estimates based on CPUC filings, provided to author by e-mail, March 18, 2004.
- ⁴⁰ Major Appliance Resource Management Alliance, “Appliance Recycling in North America: Infrastructure and Challenges,” Washington, D.C., undated.
- ⁴¹ Glynnis Jones (*op cit*), by e-mail, March 19, 2004.
- ⁴² Glynnis Jones (*op cit*), by e-mail, March 19, 2004.
- ⁴³ Appliance Recycling Information Center, “Recycling Major Home Appliances.”
- ⁴⁴ Appliance Recycling Information Center, “Recycling Major Home Appliances;” Natural Resources Defense Council. *Out With the Old, In With the New*, 12; Science Applications International Corporation *Metallic Discards in California*, 4.5.
- ⁴⁵ Natural Resources Defense Council. *Out With the Old, In With the New*, 15.
- ⁴⁶ California Integrated Waste Management Board, *Metallic Discards Management Plan*, ii.
- ⁴⁷ Science Applications International Corporation, *Metallic Discards in California*, 7.1.
- ⁴⁸ Science Applications International Corporation, *Metallic Discards in California*, 7.1.
- ⁴⁹ California Integrated Waste Management Board, *Metallic Discards Management Plan*, August 1993, i.
- ⁵⁰ California Integrated Waste Management Board, “Report on Implementation of the Recommendations of the Metallic Discards Task Force,” June 20, 1995, 9-10.
- ⁵¹ California Integrated Waste Management Board, “Report on Implementation of the Recommendations of the Metallic Discards Task Force,” 10.

-
- ⁵² California Integrated Waste Management Board, "Report on Implementation of the Recommendations of the Metallic Discards Task Force," 10.
- ⁵³ California Integrated Waste Management Board, "Metallic Discards: Task Force and Case Studies," 8.
- ⁵⁴ California Integrated Waste Management Board, "Metallic Discards: Task Force and Case Studies," 9.
- ⁵⁵ Robert Aragon, Senior Hazardous Substances Engineer, Task Force Support/Special Investigations Branch, Department of Toxic Substances Control, e-mails to author, March 2, 2004 and February 25, 2004.
- ⁵⁶ Robert Aragon, Department of Toxic Substances Control, Task Force Support/Special Investigations Branch, "Metallic Discard Summary Report," memorandum to Steve Sterling, Branch Chief, December 2, 2003.
- ⁵⁷ Appliance Recycling Information Center (ARIC), "Mercury in Home Appliances."
- ⁵⁸ Science Applications International Corporation, *Metallic Discards in California*, 3-2.
- ⁵⁹ California Integrated Waste Management Board, "Metallic Discards: Task Force and Case Studies," 9.
- ⁶⁰ Department of Toxic Substances Control, undated and unsigned memo accompanying 1997 recycler inspection reports, provided to the California Research Bureau in March 2004.
- ⁶¹ Edwin F. Lowry, Director, Department of Toxic Substances Control, letter to author, April 21, 2004.
- ⁶² Science Applications International Corporation, *Metallic Discards in California*, 7-1.
- ⁶³ U.S. Energy Information Administration, "Voluntary Reporting of Greenhouse Gases 1997," Report DOE/EIA-0608(97), <http://www.eia.doe.gov/oiaf/1605/vr98rpt/front.html>.
- ⁶⁴ California Environmental Protection Agency, "Safe Drinking Water and Toxic Enforcement Act of 1986 Chemicals Known to the State to Cause Cancer or Reproductive Toxicity," Office of Environmental Health Hazard Assessment, March 14, 2003, http://www.oehha.ca.gov/prop65/prop65_list/files/31403LSTA.pdf.
- ⁶⁵ Agency for Toxic Substances and Disease Registry, "Used Mineral-Based Crankcase Oil," CAS #8002-05-9, September 1997, <http://www.atsdr.cdc.gov/toxfaq.html>.
- ⁶⁶ California Integrated Waste Management Board, "Used Oil Recycling Rate Annual Report: 2002," Used Oil Recycling Program, <http://www.ciwmb.ca.gov/UsedOil/RateInfo/default.htm>, January 2004.
- ⁶⁷ Agency for Toxic Substances and Disease Registry, "Mercury," CAS #7439-97-6, April 1999, <http://www.atsdr.cdc.gov/toxfaq.html>.
- ⁶⁸ California Environmental Protection Agency, "Safe Drinking Water and Toxic Enforcement Act of 1986 Chemicals Known to the State to Cause Cancer or Reproductive Toxicity."
- ⁶⁹ Agency for Toxic Substances and Disease Registry, "Mercury."
- ⁷⁰ Vermont Department of Environmental Conservation, *Household Appliance Mercury Switch Removal Manual*, Spring 2002, 1.
- ⁷¹ Agency for Toxic Substances and Disease Registry, "Mercury."
- ⁷² U.S. Environmental Protection Agency, "California Report: 2001 Toxics Release Inventory," U.S. EPA Region 9, June 2003, <http://www.epa.gov/region09/toxic/tri/report/>.
- ⁷³ Department of Toxic Substances Control, "Mercury in the Environment," Doc. No. 623, undated brochure, <http://www.dtsc.ca.gov/PollutionPrevention/mercury-brochure.pdf>.
- ⁷⁴ Department of Toxic Substances Control, *Mercury Report*, Hazardous Waste Management Program, State Regulatory Programs Division, August 2002, 3-4.
- ⁷⁵ Department of Toxic Substances Control, *Mercury Report*, 3-4.
- ⁷⁶ Department of Toxic Substances Control, *Mercury Report*, 3.

-
- ⁷⁷ California Environmental Protection Agency, “Safe Drinking Water and Toxic Enforcement Act of 1986 Chemicals Known to the State to Cause Cancer or Reproductive Toxicity.”
- ⁷⁸ California Integrated Waste Management Board, *Metallic Discards Management Plan*, 5; Agency for Toxic Substances and Disease Registry, “Polychlorinated Biphenyls,” February 2001, <http://www.atsdr.cdc.gov/toxfaq.html>.
- ⁷⁹ Agency for Toxic Substances and Disease Registry, “Polychlorinated Biphenyls.”
- ⁸⁰ U.S. Environmental Protection Agency, “Background Information on PCB Sources and Regulation,” November 12, 1998, updated October 4, 1999, <http://www.epa.gov/glnpo/bnsdocs/pcbsrce/pcbsrce.html>.
- ⁸¹ California Integrated Waste Management Board, *Appliance Recycling Guide*, 13.
- ⁸² U.S. Environmental Protection Agency, “Background Information on PCB Sources and Regulation.”
- ⁸³ U.S. Environmental Protection Agency, “California Report: 2001 Toxics Release Inventory.”
- ⁸⁴ U.S. EPA, letter from Office of Pesticides and Toxic Substances to state environmental agencies, October 1998, cited in Appliance Recycling Information Center, “Recycling Major Home Appliances.”
- ⁸⁵ California Integrated Waste Management Board, *Metallic Discards Management Plan*, 6.
- ⁸⁶ U.S. Environmental Protection Agency, “Background Information on PCB Sources and Regulation.”
- ⁸⁷ California Integrated Waste Management Board, “Phase I Report – Results of Screening Analyses of 224 California MSW Landfills,” GeoSyntec Consultants, Inc., October 2003, <http://www.ciwmb.ca.gov/Landfills/ComplyStudy/Deliverables/Drafts/PhaseI.pdf>.
- ⁸⁸ California Department of Toxic Substances Control, *Draft Report: California’s Automobile Shredder Waste Initiative*, 15; Marla Jo Fisher, “Junkyard gets permit to operate until 2018,” *Orange County Register*, August 29, 1995, B2.
- ⁸⁹ Peter Wood, Senior Hazardous Substances Specialist, Statewide Compliance Division, California Department of Toxic Substances Control, personal communication, March 4, 2004.
- ⁹⁰ Peter Wood, Department of Toxic Substances Control, personal communication, March 4, 2004.
- ⁹¹ Peter Wood, Department of Toxic Substances Control, personal communication, March 4, 2004.
- ⁹² California Department of Toxic Substances Control, *Draft Report: California’s Automobile Shredder Waste Initiative*, 15.
- ⁹³ California Department of Toxic Substances Control, *Draft Report: California’s Automobile Shredder Waste Initiative*.
- ⁹⁴ California Department of Toxic Substances Control, *Draft Report: California’s Automobile Shredder Waste Initiative*, 7, 10.
- ⁹⁵ Peter Wood, California Department of Toxic Substances Control, personal communication, March 4, 2004.
- ⁹⁶ Peter J. Wood, “California’s Auto Shredder Initiative,” presentation materials, Department of Toxic Substances Control, April 15, 2004.
- ⁹⁷ Department of Toxic Substances Control, *Mercury Report*, 71.
- ⁹⁸ Lowry, letter to author, April 21, 2004.
- ⁹⁹ Science Applications International Corporation, *Metallic Discards in California*, 7.1.
- ¹⁰⁰ SB 20, Sher, 2003.
- ¹⁰¹ California Integrated Waste Management Board, “Used Oil Recycling Program,” April 16, 2004, <http://www.ciwmb.ca.gov/UsedOil/>.

-
- ¹⁰² Science Applications International Corporation, *Metallic Discards in California*, 7.11-7.12.
- ¹⁰³ California Health and Safety Code Section 25212(d)(1)(B), added by SB 633 (Sher, 2001).
- ¹⁰⁴ Science Applications International Corporation, *Metallic Discards in California*, 7-1.
- ¹⁰⁵ 22 CCR Division 4.5, Chapter 11, Section 66261.50.
- ¹⁰⁶ Green Lights Recycling, Inc., “Ballast Facts,”
<http://www.greenlightsrecycling.com/Ballast%20Facts.htm>.
- ¹⁰⁷ California Environmental Protection Agency, “Chemicals Known to the State to Cause Cancer or Reproductive Toxicity,” Office of Environmental Health Hazard Assessment, April 16, 2004,
http://www.oehha.ca.gov/prop65/prop65_list/files/P65single041604.pdf.
- ¹⁰⁸ Agency for Toxic Substances and Disease Registry, “Di(2-ethylhexyl)phthalate (DEHP),” CAS #117-81-7, September 2002, <http://www.atsdr.cdc.gov/tfacts9.html>.
- ¹⁰⁹ Natural Resources Defense Council, *Out With the Old, In With the New*.