

# DUQUESNE UNIVERSITY

## Campus Waste Minimization Plan

Prepared by: Environmental Health and Safety Department

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### 1.0 PURPOSE

Waste Minimization (WM) and Pollution Prevention (P2), efforts can save money as well as protect our environment. When materials and products are used more effectively, resources are conserved and there is a reduction in waste generation, and pollution overall. A WM plan can strengthen existing health and safety programs in the laboratory by exposing personnel to smaller amounts of hazardous chemicals and wastes generated. Ultimately, a WM plan is a regulatory requirement. The Environmental Protection Agency (EPA) states in 40 CFR 262.27(b) that a small quantity generator must make a good faith effort to minimize the waste generation and select the best waste management method that is available to us and that we can afford.

WM should be viewed as part of total quality management and should not compromise the need to meet health and safety standards or good laboratory practices. It should become part of your management and operations system, and focus on short and long-term opportunities to reduce waste and save money. As environmental awareness increases and environmental requirements become stricter, WM will become synonymous with good business sense.

There are several avenues to accomplish WM. This plan will take you through the components of WM and techniques that can be followed to achieve WM.

## 2.0 SCOPE

The scope of the WM Plan covers all individuals that are generating any waste at Duquesne University, whether the waste is hazardous, non-hazardous, biological, or radioactive.

## 3.0 WASTE OVERVIEW

Waste minimization activities apply not only to wastes but include the management of releases to air, water, and generation of solid and non-hazardous waste. While specific practices are not addressed by regulation some best practices can be implemented to reduce waste generation at Duquesne University. Waste minimization techniques can contribute to a safer workplace, help reduce operating costs by minimizing waste, save money by preventing the costly clean-ups caused by pollution, reduce or eliminate pollution costs and have a positive impact on the environment.

### 3.1 Universal Waste

All facilities that accumulate certain wastes, including batteries and mercury containing lamps (e.g., fluorescent light bulbs) are subject to the universal waste management requirements in 40 CFR 273, which include:

- Following procedures for managing waste batteries in such a way that: batteries showing evidence of leakage, spillage or damage are stored in appropriate containers; the integrity of each battery cell of batteries undergoing activities including (but not limited to) sorting, regenerating, and disassembly, is preserved; and wastes resulting from regeneration/ disassembly are properly characterized.
- Following procedures for storing waste lamps (whether they are intact or broken) in such a way that they are properly contained. The container(s) must be structurally sound, adequate to prevent breakage or, in the case of broken waste lamps, leakage; and compatible with the contents of the container.
- Labeling, as appropriate, the wastes: "Waste Batteries," "Universal Waste-Batteries," "Used Batteries," "Universal Waste-Lamp(s)," "Waste Lamps(s)," or "Used Lamp(s)."
- Tracking the length of time universal waste accumulates, to ensure that the waste does not accumulate for more than one year (unless the facility can demonstrate that accumulating universal wastes for more than one year is necessary to facilitate proper recovery, treatment or disposal).
- Providing universal waste training to employees that covers responsibilities for universal waste handling and emergency procedures.
- Containing all universal waste releases and determining whether any released material is hazardous waste.

#### Batteries

EHS is responsible for collecting, segregating, and disposing of all batteries from Duquesne University. EHS will accept all rechargeable batteries, alkaline batteries, and batteries from DU vehicles, equipment, etc.

#### Rechargeable Batteries

Commonly found in cordless power tools, cellular and cordless phones, laptop computers, camcorders, digital cameras, and remote toys. Rechargeable batteries include the following battery chemistries: Nickel Cadmium (Ni-Cd), Nickel Metal Hydride (Ni-MH), Lithium Ion (Li-ion) and Small Sealed Lead (Pb; <2 pounds). Such batteries can be sent through

interoffice mail to B-8 Mellon Hall. All rechargeable batteries are stored until there are enough for a shipment. Duquesne University has an account with the national program, *Call2Recycle*<sup>TM</sup>, the Rechargeable Battery Recycling Corporation (RBRC). For more information on battery recycling, please visit the RBRC website at [www.rbrc.org](http://www.rbrc.org).

#### Alkaline and Other Small Batteries

These can also be sent through interoffice mail to B-8 Mellon Hall. Other small batteries would include the following chemistries: Lithium, Lithium Sulfur Dioxide (LiSO<sub>2</sub>), and Zinc Chloride. These batteries are shipped off campus, as needed, through our hazardous waste vendor.

#### Large Lead Batteries from DU Vehicles and Equipment

These must be handled differently due to their size and weight. However, before claiming these batteries as waste, exhaust the following step: for equipment/vehicle batteries – prior to purchasing a new battery, exhaust the possibility of the company taking the old battery (take-back). If they will not accept the old battery, then contact the EHS office for further instructions.

#### Lamps

Lamp, also referred to as "universal waste lamp," is defined as the bulb or tube portion of an electric lighting device. A lamp is specifically designed to produce radiant energy, most often in the ultraviolet, visible, and infra-red regions of the electromagnetic spectrum. A lamp, bulb or tube portion in an electrical lighting device, contains a small amount of mercury and small amounts of cadmium can also be present in some types of lamps. For these reasons, they must be managed as universal waste.

There are several shapes and sizes of lamps available. Small compact, U-tubes, circular, four foot straight, eight foot straight, and standard light bulb shapes are all very common. Lamps regulated as universal waste can be fluorescent, high intensity discharge, neon, mercury vapor, high pressure sodium, and metal halide lamps.

A used lamp becomes a waste the day it is discarded, sent for reclamation, and an unused lamp becomes a waste when the handler decides to discard it.

A small quantity handler of universal waste must manage lamps in a way that prevents releases of any universal waste or component of a universal waste to the environment, as follows:

- (a) Contain any lamp in containers or packages that are structurally sound, adequate to prevent breakage, and compatible with the contents of the lamps. Such containers and packages must remain closed and must lack evidence of leakage, spillage or damage that could cause leakage under reasonably foreseeable conditions.
- (b) Immediately clean up and place in a container any lamp that is broken or any lamp that shows evidence of breakage, leakage, or damage that could cause the release of mercury or other hazardous constituents to the environment.

#### Used Oils

##### *Outdoor Handling of Material*

To minimize the likelihood of discharge of pollutants to storm water from outdoor loading and unloading of material, adhere to the following best practices.

- Avoid transferring materials close to storm drain inlets.
- Transfer liquids only in paved areas.
- Protect all loading/unloading activities from rainfall, run-on and wind dispersal to the maximum extent practicable. Viable options include conducting loading/unloading under existing cover, or moving indoors.
- Maintain adequate supplies of spill response equipment and materials in accessible locations near areas where spills may be likely to occur.
- Clean-up minor spills immediately.
- Conduct regular inspections of storage and containment equipment and promptly correct deficiencies to this equipment as necessary.

#### *Outdoor Storage of Material*

Storing material outdoors, whether it is equipment, chemicals, or containers, can result in potential storm water contamination. Follow these best practices to minimize potential impact to storm water runoff.

- Avoid dispensing from drums positioned horizontally in cradles. Dispensing materials from upright drums equipped with hand pumps is preferred. Always use drip pans and self-closing spigots if dispensing from horizontally positioned drums.
- Store drums and containers on pallets or other structures to keep the container out of contact with storm water.
- Store all material in their original containers or containers approved for that use. Ensure that all containers are appropriately sealed. Store empty containers indoors or under cover before moving them off-site.
- Properly label all chemical containers with information, including their contents, hazards, spill response and first aid procedures, manufacturer's name and address, and storage requirements. Maintain copies of MSDS on file for any materials stored and/or handled.
- Reduce the quantities of chemicals stored outside to minimum volume required based on variables such as release potential, usage, storage capacity, and chemical shelf life.
- Maintain adequate supplies of spill response equipment and materials in accessible locations near areas where spills may be likely to occur.
- Post signs at all chemical storage locations in clearly visible locations noting the materials stored, emergency contacts, and spill cleanup procedures.
- Perform and document periodic inspections. Inspection items should include the following: external corrosion, structural failure, spills and overfills due to operator error, failure of piping system (pipes, pumps, flanges, couplings, hoses, and valves), visually inspect new tanks or containers for loose fittings, poor welds, and improper or poorly fitted gaskets, and inspect tank foundations and storage area coatings.

#### *Waste Handling and Disposal*

Best practices related to waste handling and disposal include the following suggested activities.

- Perform regular housekeeping activities in waste storage areas.
- Reuse or recycle materials whenever possible.

- Inspect waste management areas for spills and waste management containers for leaks.
- Track waste generated, evaluate the process generating the waste and look for ways to reduce waste generation.
- Characterize waste streams.
- Find substitutes for harmful chemicals; properly dispose of unusable chemical inventory.
- Segregate and separate wastes.
- Do not dispose of liquid wastes such as oils or hazardous materials into dumpsters.
- Maintain adequate supplies of spill response equipment and materials in accessible locations near areas where spill may be likely to occur.
- Perform and document periodic inspections. Inspection items should include the following: external corrosion, structural failure, spills and overfills due to operator error, failure of piping system (pipes, pumps, flanges, couplings, hoses, and valves), visually inspect new tanks or containers for loose fittings, poor welds, and improper or poorly fitted gaskets, and inspect tank foundations and storage area coatings.

#### *General Maintenance/Repair Work*

When performing general vehicle repair/maintenance work near floor drains, implement the following to the maximum extent practical:

- Drain and crush oil filters (and oil containers) before recycling or disposal. Store crushed oil filters and empty lubricant containers in a leak-proof container.
- Drain and properly dispose of all fluids and remove batteries from vehicles, and equipment.
- Recycle or properly dispose of the following: greases, oils, antifreeze, brake fluid, cleaning solutions, hydraulic fluid, batteries, transmission fluid, and filters.
- Use biodegradable products and substitute materials with less hazardous properties where feasible.
- Maintain clean equipment by eliminating excess amounts of external oil and grease buildup. Use water-based cleaning agents or non-chlorinated solvents to clean equipment.
- Store mechanical parts and equipment that may yield even small amounts of contaminants (i.e., oil or grease) away from drains.
- Sweep or vacuum the shop floor frequently.
- Designate specific areas indoors for parts cleaning.
- Clean up any spills promptly.
- Keep rags, mops, absorbents, and other cleanup supplies readily accessible to all work areas.
- Never sweep or flush wastes into a floor drain.
- Promptly transfer drained fluids to a designated waste storage area.
- Place bulk fluids, waste fluids, and batteries in secondary containment to capture accidental spills.
- Service “pits” should have concrete floors and not earthen floors or floors with drains.

## 3.2 Hazardous Waste

Waste profiling is the determination of a waste. This is generally done by the scientist who is generating the waste. They are primarily responsible for identifying the components in the waste stream. The scientist is responsible for compiling a list of all known or suspected hazardous components in their waste. According to 40 CFR 261, the EPA specifies waste as hazardous if they appear on one of four lists (P-list, K-list, F-list, or U-list) or exhibit a particular hazardous characteristic. For laboratories, the most relevant listings are those for spent solvents (a portion of the F-list) and discarded commercial chemical products (known as P- and U-lists). Spent solvents on the F-list are designated by the codes F001, F002, F003, F004, and F005 and include common solvents such as acetone, methanol, methylene chloride, toluene, and xylene. The P- and U-lists apply to unused, discarded commercial chemical products with a sole active ingredient on one of the two lists. Expired or unused laboratory chemicals are often P- or U-listed wastes. There are two classes of wastes: listed and characteristic.

**3.2.1 Listed Wastes** are generated from specific processes or contain a hazardous constituent. An example would be any spent halogenated wastes – methylene chloride or trichloroethylene. Some of these listed wastes are considered “acute hazardous wastes”. Acute hazardous wastes are very toxic and can be fatal to humans in small amounts.

**3.2.2 Characteristic Wastes** demonstrate having certain hazard characteristics. The EPA has test procedures to identify such characteristics. They include the following:

- a. Ignitability – generally liquids with a flashpoint below 140°F.
  - a. Flammable Liquids – alcohols, benzene, toluene, acetonitrile
  - b. Oxidizers – nitrates, perchlorates, bromates, permanganates, perox, iodates
  - c. Organic Peroxides – benzoyl peroxide, cumene hydroperoxide, ethyl ketone peroxide
- b. Corrosivity – aqueous solutions with a  $\text{pH} \leq 2$  or  $\geq 12.5$ .
  - a. Inorganic Acids – hydrochloric acid, sulfuric acid, nitric acid, perchloric acid, phosphoric acid
  - b. Organic Acids – formic acid, lactic acid
  - c. Bases – hydroxide solutions, amines
- c. Reactivity – unstable, explosive, or water reactive.
  - a. Sulfides and cyanides
  - b. Peroxide Formers – ethers, potassium amide, sodium amide, tetrahydrofuran
  - c. Alkali Metals – sodium, potassium, lithium
  - d. Dinitro- and Trinitro- Compounds – picric acid
  - e. Carbonyl Compounds
  - f. Isocyanates
  - g. Perchlorate Crystal Formers – perchloric acid
- d. Toxicity – contain one or more of 40 regulated toxic constituents (any detectable amount of these chemicals must be identified as hazardous waste).
  - a. Eight Heavy Metals
  - b. Ten Pesticides
  - c. Twenty Two Organic Chemicals

Radioactive and biological wastes are not included as a characteristic waste. These wastes fall under different regulations.

### 3.3 Miscellaneous Waste

#### Aerosols/Paint Management

A system must be established to use, store, and dispose of aerosol cans and paint before they become a problem. Examples of materials contained in aerosol cans and paint materials in a ground/vehicle maintenance facility include, but are not limited to:

- Brake cleaners
- Spray paints
- Miscellaneous lubricants (i.e., WD-40)
- Used paint
- Old cans of previously used paint

Some examples to follow as best management practices include the following:

- Implement a “first in , first out” use pattern for aerosol cans and order new cans on an as needed basis to ensure that cans are used up prior to opening new cans.
- Carefully determine whether spent aerosol cans are hazardous or non-hazardous. If contents and/or propellant remain(s) in the can, it is likely hazardous waste; if there is neither content nor propellant, then it is likely a non-hazardous waste.
- To minimize disposal costs, ensure that truly empty aerosol containers are either sent to a scrap-metal recycler or disposed of in the trash.
- Minimize excess liquid paint by making efficient use of paint “pouring” for use (i.e., use what you pour).

#### Solvents/Parts Washing

Parts washing involves the cleaning of metal parts with a solvent. Many spent solvents are hazardous waste and therefore certain environmental regulations pertain. There are environmentally friendly products on the market that do not contain chlorinated solvents; and therefore the need to comply with certain environmental regulations would be eliminated.

To assist in reducing potential impacts to the environment or worker exposure from parts cleaning, the following best practices should be followed:

- Keep the parts cleaner closed when not in use.
- Reduce solvent evaporation by increasing freeboard and placing hoods or covers on all parts cleaning tanks.
- Utilize less toxic non-chlorinated solvent cleaners or aqueous-based cleaners to reduce worker exposure and hazardous waste generation.
- Use one multi-purpose solvent instead of many different solvents to increase recycle potential of the solvent.
- Consider using a service to maintain your parts cleaning unit.
- Consider pre-cleaning parts with a rag or wire brush.
- Reuse or recycle materials whenever possible. Recycle automotive fluids, solvents, cleaners, absorbents, and wash waters when the useful life is finished.
- Inspect parts cleaner system for spills or leaks.
- Properly dispose of unused chemical inventory
- Maintain adequate supplies of spill response equipment and materials in accessible locations near areas where spills may be likely to occur.

Reduce hazardous waste generation by minimizing the potential for cross-contaminating of wastes by ensuring, for example, that parts cleaners that do not contain listed wastes are

segregated from listed wastes from other sources (for example, aerosols); and that non-hazardous materials (i.e., rags, oils, etc.) are not contaminated by parts washer solvents that are listed hazardous waste.

### Pesticides

Pesticides are covered under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). FIFRA regulates the registration, labeling and packaging of pesticides, as well as worker protection and applicator certification. Proper use and storage of pesticides are critical both for human health on the job and for protecting the environment.

Best practices related to pesticides include the following:

- Keep pesticides dry and out of the way of activities that might puncture or knock over a jug or rip open a bag or box.
- Put a curb around the floor to prevent chemicals from spreading to other areas, if pesticides spill.
- If a spill does occur, an impermeable (waterproof) floor, such as concrete, should virtually eliminate any seepage of chemicals into the ground. Cleanup should be immediate because many pesticides will penetrate and be absorbed into concrete.
- Post best management practices related to pesticides on the walls of the grounds/vehicle maintenance facility so that they are easily accessible and remind the staff to handle pesticides properly.
- Secondary containment provides an impermeable floor and walls around the storage area, which will minimize the amount of pesticide seeping into the ground if a bulk liquid pesticide storage container should leak.
- Mixing/loading pads provide secondary containment during the dilution or transfer of pesticides to spraying equipment or nurse tanks.
- Store pesticides in original containers that are closed, labeled, and in a secure area out of reach of children and pets.
- Use rubber gloves when handling pesticides.
- Do not use or give away banned pesticides or pesticides that are no longer registered for use.
- Do not reuse pesticide containers.
- Disposal of pesticide wastes, unused pesticides, residue, and cleanup materials needs to be evaluated to determine if there are any applicable RCRA hazardous waste requirements.

### Vehicle and Equipment Washing

Vehicle and equipment washing have the potential for contaminating receiving waters through the discharge of grit, oil and other contaminants. State and Federal regulations have strict guidelines concerning the discharge of vehicle wash water.

- Soapy or oily vehicle wash waters must either be collected for off-site disposal or discharged to the sanitary sewer, if not allowed by the local sewer authority.
- Consider using a commercial car wash if your area is not equipped properly.

### Vehicle Use

Colleges and Universities with a large grounds and maintenance fleet can have a significant impact on the environment; impacts such as air pollution and use of natural resources. While there are very few environmental regulations that govern vehicle use, the following are best practices that can be followed.



- Keep tire pressure at the recommended level to improve fuel efficiency.
- Make certain that the vehicle's exhaust meets inspection requirements to minimize impacts to air quality.
- Ensure that your equipment/vehicles undergo regular tune-ups, and change the oil frequently. This will prevent your car's gas mileage from declining as it gets older and extends the life of the vehicle.
- Avoid making off-campus errands during rush hours. Congested conditions with their slow speeds, frequent acceleration, and stop-and-go movement increase air pollution. Also, if you find yourself doing multiply errands off-campus throughout the day, try to combine the errands. When you first start a car after it's been sitting for more than an hour, it pollutes up to five times more than when the engine is warm.
- Buy "green" vehicles.
- Avoid idling; this will conserve fuel.

### Recycling

In an effort to provide employees, students, faculty, staff and visitors with the most efficient recycling options possible, Facilities Management has initiated a comprehensive integrated recycling management program for all of our facilities. Their overall goal is to reduce the amount of waste that goes to landfills by recycling and using it for other means. They have recently increased the amount of recycle friendly containers in visible, easy to access areas in all of our buildings, which permit both product separation and commingling of all paper grades, plastic and metal. The recycling of cardboard is accomplished by collecting the items and then using a compactor. The resulting compacted items are then recycled. All materials are picked up weekly by a local recycling vendor and taken to their plant for separation and processing.

Other recycled items include ink cartridges and computer equipment. Ink cartridges can be sent back to the supplier. For example, those who use Hewlett Packard (hp) printers – if you visit their website at [www.hp.com/recycle](http://www.hp.com/recycle) you can find out more information. All computer equipment is recycled through CTS. Your computer should first be cleaned of all old files, which would need to be scheduled through the CTS Help Desk at x4357 (HELP). Once your machine is cleaned, a Maximo will need to be submitted online to Facilities Management. FM will then pick-up all of the equipment.

## **4.0 COMPONENTS OF THE WASTE MINIMIZATION PLAN**

There are several components involved in making a WM plan work. First there has to be upper management support. From the upper management support, there should be an overall employee participation. Most of that will be gained through open communication, trainings, and waste audits, as discussed below.

### **4.1 Management Support and Employee Participation**

A clear commitment by senior management through policy, communications, and resources, to WM is essential to earning the dedication of all employees. For this to happen, a formal policy statement must be drafted and adopted. The purpose of this statement is to reflect the laboratories', departments', and ultimately the University's commitment and attitude toward protecting the

environment, minimizing or eliminating waste, and reuse or recycling of materials. Creative, progressive, and responsible leadership will serve to develop environmental policy; however, the total employee workforce will need to be involved.

## **4.2 Training**

Training employees on the proper way to use, handle, and store hazardous materials can reduce the amount of waste generated. The employee will learn how to use proper amounts thus reducing enormous amounts of generated waste. Proper handling techniques will reduce leaks and spillages that are a source of waste. The training will also give the employee self-assurance that he or she is valued by the university.

## **4.3 Waste Audits**

Conducting waste audits is a good way to keep up on what is happening within the laboratory setting. Waste audits can provide a systematic and periodic survey of the university's operations and can identify additional areas of potential waste reduction. A waste audit includes the identification and inventory of hazardous waste and the sources of these wastes, the prioritization of various waste reduction actions to be undertaken, the evaluation of technical solutions, economically and ecologically feasible approaches to WM, the development of an economic comparison of WM options, and the evaluation of their results.

## **5.0 WASTE MINIMIZATION TECHNIQUES**

There are six main techniques to minimize waste generation. They include:

1. Good Housekeeping
1. Separation and Segregation
2. Recycling and Reuse
3. Inventory, Purchasing Controls and Source Reduction
4. Substitution
5. Microscale Chemistry/Process Modification

### **5.1 Good Housekeeping**

Good housekeeping is the simplest way to minimize waste generation. Examples include:

- Avoid spilling or dripping chemicals that would need to be cleaned up.
- Use only unbreakable containers, when possible.
- Always use carts to transport chemicals.
- Use secondary containment devices to contain spills.
- Always label all containers with the contents and date.

### **5.2 Separation and Segregation**

Keep hazardous wastes separate from other wastes – no mixing. Do not mix hazardous and non-hazardous wastes – segregate the waste streams. For example, halogenated and non-halogenated wastes should be kept separate. Mixing of biological and hazardous wastes or radioactive and hazardous wastes is very expensive to dispose of.

The table below shows the hierarchy of storage groups; this table can be used when separating incompatible chemicals.

Hierarchy of Storage Groups	
1. Radioactive Materials A1	11. Non Flammable – Non Toxic Gas G4
2. Explosive E1	12. Flammable Liquid F1
3. Herbicides P1	13. Oxidizers R1
4. All other Pesticides P2	14. Pyrophoric R4
5. Flammable – Toxic Gas G1	15. Waste Reactive R3
6. Non Flammable – Toxic Gas G3	16. Reducers R2
7. Flammable – Non Toxic Gas G2	17. Corrosive Acid C1
8. Acetylene Gas G7	18. Corrosive Base B1
9. Oxygen/Oxidizer G6	19. Toxic Chemicals T1
10. Chlorine Gas G5	

The table below demonstrates what groups can be stored together

F1	C1	B1	R3	G6	G7	A1
E1	R2	T1	R1	R4	P1, P2	G 1-5

### 5.3 Recycling and Reuse

Recycling can take several forms. One is the actual “recovery” of a “used” substance (i.e. solvents). Once recycled, these materials, even though they may be less pure, can be used in other processes or experimentation where high quality is not an issue. Another means of recycling is to develop an “orphan” chemical system whereby unneeded chemicals from one department can be given to another lab or department. Practice recycling whenever possible. Examples include:

- Mixtures of used alcohols can sometimes be used in preparing standard solutions.
- Used nitric and sulfuric acids from ion exchange columns can sometimes be used as a pre-cleaning rinse on another column.

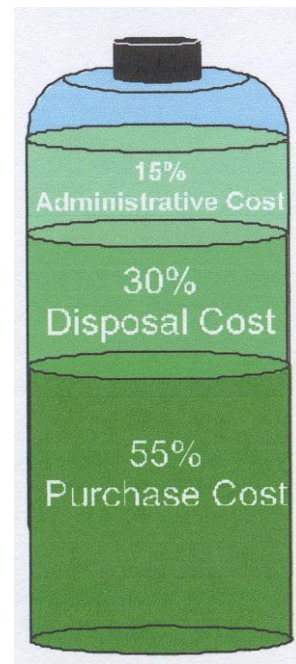
### 5.4 Inventory, Purchase Controls and Source Reduction

Inventory and purchase controls help reduce the disposal of old, expired chemicals, as well as over ordering items. Purchasing chemicals in larger containers at an initial lower cost, rather than smaller containers, appears to be a good way to save money. However, consideration of the total costs of such purchases makes it clear this may not be the case. When a large container of a chemical is purchased, often a small quantity is taken out for use and the rest is stored. As a result, partially filled containers accumulate in laboratories and storerooms, and the chemicals – many of which have exceeded safe storage time periods or have unreadable labels – are disposed of as waste.

In a laboratory that has not adequately implemented WM programs, unused chemicals typically constitute 40% or more of the hazardous waste stream generated. Costs incurred as a result of these unneeded chemicals include analysis, storage, packaging, transport, and disposal. When labels are missing or unclear, the cost of having even a small amount of an unknown chemical analyzed prior to disposal will far exceed the purchase prices of an entire container of the materials.

Furthermore, long-term storage of unused chemicals increases the risk of accidents. Also, smaller bottles are sturdier than larger ones, so breakage and spill risks are substantially reduced. If bottles do break, there is less spillage, making clean-up safer, easier, and less expensive.

The figure on the right demonstrates a cost overview per one container of chemical purchased:



There are several ways to control one's inventory and purchasing. To start, one should conduct a lab clean out. These are necessary to get rid of expired, excess, or unwanted items. Every lab should have a schedule of cleanouts (i.e. each semester, annually) and always assess results from previous cleanouts. A more involved control mechanism would be to purchase a system that monitors requisitions to prevent the purchase of hazardous chemicals, for which safer substitutions are available.

**Other Examples:**

1. avoid over ordering reagents, especially those with a short shelf life;
2. order only the amount needed;
3. make sure all containers are clearly labeled;
4. use older materials first, to avoid expiration;
5. share chemicals and stocks;
6. conduct periodic lab clean outs

The Myth of Buying in Bulk

If 1000 ml of phenol are used...

	Two 500 ml bottles	One 2500 ml bottle
Catalog unit cost	7.2 cents/ml	5.5 cents/ml
Purchase cost	\$72.00	\$137.00
Lab pack disposal cost	\$0.00	\$27.66
Total cost of the chemical	\$72.00	\$164.66

True Cost = Sum of Purchase + Disposal + Labor + Liability + Compliance Costs

**5.5 Substitution**

In recent years, most laboratories have minimized waste generation by substituting less hazardous chemicals for more hazardous chemicals. Substitution is a good method to use, which entails substituting a non-hazardous reagent, catalyst or solution for a hazardous one. An example would be how acid cleaning solutions can be replaced with detergents or ultrasonic cleaning systems. However, in the academic setting, identifying viable chemical substitutes may be difficult. Contact with colleagues or chemical suppliers may be useful in obtaining information on potential substitutions. Another resource of information would be the Integrated Solvent Substitution Data Systems (ISSDS), which can be found at <http://es.epa.gov/issds/index.html>. Below are some examples of common substitutions:

1. Cyclohexane can often substitute for the more toxic benzene;
2. Hydrocarbon solvents may serve in the place of their halogenated counterparts;
3. Aqueous solvents are increasingly replacing hydrocarbons as the reaction media of choice;
4. Alcohols can replace benzene;

5. Cyclohexane can replace carbon tetrachloride;
6. Sodium hypochlorite can replace sodium chromate.

Common Chemical Substitutions

Original Material	Substitute	Comments
Acetamide	Stearic acid	In phase change and freezing point depression
Benzene	Alcohol	Determination of molecular weight by freezing point depression
Benzoyl peroxide	Lauryl peroxide	When used as a polymer catalyst
Carbon tetrachloride	Cyclohexane	In test for halide ions
Formaldehyde	Peracetic acid	In cleaning of kidney dialysis machines
Formaldehyde	Formalernate Flinn Scientific	For storage of biological specimens
Formaldehyde	Ethanol	For storage of biological specimens
Formalin	See Formaldehyde	
Halogenated Solvents	Nonhalogenated Solvents	In parts washers or other solvent processes
Mercuric chloride reagent	Amitrole (Kepro Circuit Systems)	Circuit board etching
Sodium dichromate	Sodium hypochlorite	
Sulfide ion	Hydroxide ion	In analysis of heavy metals
Toluene	Simple alcohols and ketones	Solvents
Wood's metal	Onions Fusible alloy	
Xylene	Simple alcohols and ketones	Solvent
Xylene or toluene based liquid scintillation cocktails	Nonhazardous proprietary liquid scintillations cocktails	In radioactive tracer studies
Mercury salts	Mercury free catalysts (e.g. CuSO <sub>4</sub> TiO <sub>2</sub> K <sub>2</sub> SO <sub>4</sub> )	Kjeldahl digests

### 5.6 Microscale Chemistry/ Process Modification

Microscale chemistry is an environmentally safe pollution prevention method of performing chemical processes using small quantities of chemicals without compromising the quality and standard of chemical applications in education. Microscale chemistry is performed by using: drastically reduced amounts of chemicals, safe and easy manipulative techniques, and miniature labware and high quality skills.

The benefits of microscale chemistry include: reduction in chemical use promoting source reduction, improved lab safety (better air quality, less exposure to chemicals, no fires, no spills, etc.), reduction in laboratory costs, shorter experiment times, and saves on storage space.

Examples:

1. measurement of physical properties
2. microscale distillation and reflux

3. microscale filtration and purification
4. microscale in analytical chemistry
5. microscale synthesis and characterization
6. microscale electrochemistry

Process modification is the scaling down the magnitude of the procedures and experiments offers enormous potential for WM. Fortunately, modern laboratory instrumentation requires smaller quantities of chemicals than were used in the past to achieve satisfactory analytical results. For teaching laboratories, instructors should plan experiments based on the smallest scale possible. Microscale procedures and equipment use smaller quantities of reagents, result in smaller quantities of waste, are safer, and teach careful laboratory techniques. Try to use the minimum amounts of hazardous chemicals when necessary.

Examples:

1. Use hazardous solvents and cleaners sparingly;
2. Choose physical test methods over wet chemistry;
3. Conduct instrument and physical analysis, which generates very little waste.

## 6.0 OTHER MANAGEMENT TECHNIQUES

### 6.1 Evaporation

Evaporating small quantities (100 ml. or less) of volatile materials is a viable method for managing hazardous wastes. Such a procedure must be executed within a working fume hood and should not involve materials that yield explosive or flammable residues. Some solvents suitable for evaporation are as follows:

Acetone	1,2-Dichloroethylene	Methyl alcohol
2-Butanol	Diethyl ether	Methyl ethyl ketone
Butyl alcohol	Ethyl acetate	Pentane
Carbon tetrachloride	Ethyl alcohol	Perchloroethylene
Chloroform	Heptane	2-Propanol
Cyclohexane	Hexane	Trichloroethylene
Dichloromethane	Isopropyl alcohol	Xylene

### 6.2 Drain Disposal

No user shall introduce directly or indirectly into the public works any pollutant or wastewater which will interfere with or adversely affect the operation or performance of the Publicly Owned Treatment Works (POTW), or pass through the POTW into the waters of the Commonwealth of Pennsylvania and cause, alone or in conjunction with other discharges, a violation of any requirement of the POTW's NPDES permit, or adversely affect the use of disposal of the POTW's sludge. No user shall introduce any of the following substances in the POTW:

- **Ignitable waste.** A waste or substance which can create a fire hazard in the POTW which has any of but is not limited to the following properties:
  - It is a liquid with a flash point less than 60 degrees C (140 degrees F) using the test methods specified in 40 CFR 261.21
  - It is an oxidizer as defined in 49 CRF 173.151

- **Reactive/Explosive Waste.** A waste or substance which can create an explosion hazard in the POTW which has any of but is not limited to the following properties:
  - It is normally unstable and readily undergoes violent change without detonating.
  - It reacts violently with water.
  - It forms potentially explosive mixtures with water.
  - When mixed with water, it generates toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
  - It is a cyanide or sulfide bearing waste which can generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
  - It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.
  - It is readily capable of detonation, explosive decomposition or reaction at standard temperature and pressure.
  - It is a forbidden explosive as defined in 49 CFR 173.51, or a Class A explosive as defined in 49 CFR 173.53 or a Class B explosive as defined in 49 CFR 173.88.
- **Corrosive Waste.** A waste or substance which has any of the following properties:
  - It is aqueous and has a pH less than or equal to 5 or greater than or equal to 10, as determined by a pH meter.
  - It is a liquid and corrodes steel (SAE 1020) at a rate greater than 6.35 mm (0.250 inch) per year at a test temperature of 55C (130F).
- **Hazardous Waste.** All wastes that are defined as hazardous under the regulations enacted pursuant to the Resource Conservation and Recovery Act (RCRA) as specified in 40 CFR 261 or under the regulations promulgated pursuant to the Pennsylvania Solid Waste Management Act as specified in 25 PA Code 261, except as provided for in these regulations.
- **Thermal Waste.** Any wastewater with a temperature greater than 60C (140F). Also, heat in the amounts which will inhibit biological activity in the POTW resulting in interference, but in no case heat in such quantities that the temperature at the POTW treatment plant exceeds 27C (80F).
- **Radioactive Waste.** Any waste which exceeds the naturally occurring background levels for either alpha, beta, or gamma radiation and/or any wastewater containing any radioactive wastes or isotopes of such half-life or concentration not in compliance with applicable State or Federal regulation.
- **Solid or Viscous Substances.** Any solid or viscous substances capable of causing obstruction to the flow in sewers or other interference with the proper operation of the Authority's facilities or facilities discharging into the Authority's system.
- **Malodorous/Noxious Substances.** Any pollutants or noxious or malodorous liquids, gases, or solids which either singly or by interaction with other wastes:
  - Result in the presence of toxic gases, vapors, or fumes in a quantity that may cause acute worker health and safety problems; or
  - Are sufficient to create a public nuisance or hazard to life or are sufficient to prevent entry into the sewers for maintenance and repair.
  - Any pollutant, including oxygen demanding pollutants (BOD, etc.) released in a discharge at a flow rate and/or pollutant concentration which will cause Interference with the POTW.
  - Any substance which will cause the POTW's effluent or any other product of the POTW such as residues, sludges, or scums, to be unsuitable for reclamation processes, including any substance which will cause the POTW to be in noncompliance with sludge use or disposal criteria, guidelines, or regulations developed under Section 405

- of the Act, any criteria, guidelines, or regulations promulgated pursuant to the Solid Waste Disposal Act, the Clean Air Act, the Toxic Substances Control Act or State laws or regulations applicable to the treatment or disposal of such effluent or such product.
- Petroleum oil, nonbiodegradable cutting oil, or products of mineral oil in origin in amounts that will cause interference or pass through, notwithstanding the provisions of Section 2.4 of these regulations relating to oil and grease.

### 6.3 Treatment

If other methods of waste minimization are inappropriate for your particular situation, a final option may be chemical treatment of the hazardous waste generated during use. As part of the experiment, neutralization, precipitation, oxidation/reduction, and distillation are examples of treatment techniques that may be applied to reduce hazardous waste quantities.

**REMINDER: All of the treatment procedures identified below necessitate the involvement of an individual experienced in such activities.**

Neutralization involving acids and bases is the most common type of treatment. Adjustments in pH can be made to neutralize a highly acidic or highly alkaline solution. A final pH level of between 6 and 9 is desirable. If the solution contains no other hazardous component as defined by 40 CFR 261 (i.e. one which is toxic), the neutralized solution can be treated as normal waste and disposed of in a sanitary sewer drain.

Precipitation and oxidation/reduction reactions can remove hazardous components from waste. Disposing of these materials may then be accomplished through normal means. Precipitates from these reactions may need to be treated more effectively in a formal disposal mode. Incorporating treatment procedures as a part of experimentation within teaching laboratories serves a dual purpose. It not only reduces the hazardous wastes being produced, but it also teaches students responsible waste management. Providing students with the knowledge and understanding of correct minimization techniques would seem only to benefit the future generations of scientists. An alternative to specific destruction of hazardous wastes in teaching laboratories would be to include within another experiment the hazardous waste generated. This procedure would serve the purpose of limiting waste production as well as supplying the "raw" materials for additional experimentation.

All alternatives to waste handling methods require prior planning in order to be incorporated within teaching lab activities. The benefits of doing so would be directed to the University (minimizing risks, overall waste reduction, lowering management costs), the academic department (minimizing waste generation, limiting waste handling), and the students as well (learning proper waste management responsibility, realizing the University's commitment to the reduction of hazardous waste, safety –less accidents).

#### Bench Scale Waste Treatment

If other methods of waste minimization are inappropriate for your particular situation, a final option may be chemical treatment of the hazardous waste generated during use. Neutralization, precipitation, oxidation/reduction, and distillation are examples of treatment techniques that may be applied to reduce hazardous waste quantities. Laboratories generating hazardous waste have a few options for treating hazardous waste on site without a permit. The small-scale treatment and



deactivation of products and by-products as part of the experiment plan is one approach that can be used. Before undertaking any procedures, safety must always be the first consideration. All procedures should be carried out under the direct supervision of a trained scientist. During any procedure, personal protective equipment must be worn.

Waste Chemical	Treatment Method
Acids	Neutralize with basic waste to pH of 5-9
Acid halides and anhydrides	Hydrolyze with sodium hydroxide solution
Aldehydes and ketones	Oxidize with permanganate
Alkyl halides	Hydrolyze with ethanolic potassium hydroxide
Aromatic amines	Deaminate with hydrochloric acid and sodium nitrite
Hydroperoxides	Treat with acidified ferrous sulfate solution
Inorganic cyanides	Oxidize with aqueous sodium hypochlorite
Mercaptans, carbon disulfide	Oxidize with sodium or calcium hypochlorite
Metal azides	React with nitrous acid
Metal bearing aqueous solutions	Precipitate as metal sulfides in a neutral solution
Metal fluorides in aqueous solution	Precipitate with calcium chloride
N-nitroso compounds	Reduce with aluminum-nickel alloy in basic solution.
Oxidizers	Reduce with sodium bisulfate
Phenol	React with hydrogen peroxide and an iron catalyst.

**Treating hazardous waste on site in ways other than those provided for in the regulatory exclusions subjects generators to extremely high fines (e.g. up to \$50,000 per day) and possibly incarceration.**

## 7.0 RESOURCES

RCRA Online - <https://rcrapublic.epa.gov/rcraonline/>

EPA – Hazardous Waste – Waste Minimization -

<https://archive.epa.gov/epawaste/hazard/wastemin/web/html/faqs.html>

PA DEP – Waste Minimization -

<https://www.dep.pa.gov/Business/Land/Waste/SolidWaste/Pages/Reduction.aspx>

EPA – Colleges and Universities - <https://archive.epa.gov/sectors/web/html/college.html>

## Appendix A: 70+ Ways to Reduce Hazardous Waste in the Laboratory

1. Write and follow a WM Plan
2. Include WM as part of student and employee training
3. Use manuals as part of your training – American Chemical Society’s “ACS Less is Better” or “ACS Waste Management Manual for Laboratory Personnel”
4. Create an incentive program for WM
5. Centralize purchasing of chemicals through one person in the department, or laboratory
6. Inventory chemicals, at least once a year
7. Indicate where the chemicals are located in the inventory
8. Update inventory when chemicals are purchased or used
9. Purchase chemicals in smallest quantities needed
10. If trying out a new procedure try to obtain the chemicals needed from another laboratory or purchase small amounts initially -after you know you will be using more of these chemicals purchase in larger quantities unless you can obtain excess chemicals from someone else
11. Date chemical containers when received, so that older ones will be used first
12. Audit your laboratory for waste generated, quantity, type, source, and frequency
13. Keep MSDSs for chemicals used
14. Keep information about disposal procedures for chemical waste
15. If possible, establish a central storage for chemicals
16. Keep chemicals in your storage area except when in use
17. Establish an area for storing chemical waste
18. Minimize the amount of waste kept in storage by utilizing waste collection days
19. Keep all waste containers in secondary containment
20. Label all chemical containers as to their contents
21. Keep halogenated solvents separate from non halogenated solvents
22. Keep recyclable waste excess chemicals separate from non recyclables
23. Keep organic wastes separate from metal containing or inorganic wastes
24. Keep nitric acid wastes separate from other inorganic acid wastes
25. Keep non-hazardous chemical wastes separate from hazardous wastes
26. Keep highly toxic wastes (cyanides) separate from previous groups of wastes
27. Avoid experiments that produce wastes that contain combinations of radioactive, biological, and/or hazardous waste
28. Keep chemical wastes separate from normal trash, paper, wood, etc
29. Develop procedures to prevent and/or contain chemical spills; purchase spill clean up kits; contain areas where spill are likely to occur
30. Use the least hazardous cleaning method for glassware; use detergents such as Alconox Micro RBS35 on dirty equipment before using KOH ethanol bath, acid bath or No Chromix
31. Eliminate the use of chromic acid cleaning solutions altogether
32. Eliminate the use of uranium and thorium compounds
33. Substitute red liquid spirit filled digital or thermocouple thermometers for mercury containing thermometers where possible
34. Use a bimetal or stainless steel thermometer instead of mercury thermometer in heating and cooling units
35. Evaluate laboratory procedures to see if less hazardous or non-hazardous reagents could be used
36. Review the use of highly toxic, reactive, carcinogenic, or mutagenic materials to determine if safety alternative are feasible

37. Avoid the use of reagents containing arsenic barium cadmium chromium lead mercury selenium and silver
38. Consider the quantity and type of waste produced when purchasing new equipment
39. Purchase equipment that enables the use of procedures that produce less waste
40. Review your procedures regularly (i.e. annually) to see if quantities of chemicals and or chemical waste could be reduced
41. Look into the possibility of including detoxification and/or neutralization steps in laboratory experiments
42. When preparing a new protocol consider the kinds and amounts of waste products and determine whether they can be reduced or eliminated
43. When researching a new or alternative procedure, include consideration of the amount of waste produced as a factor
44. Examine your waste excess chemicals to determine if there are other uses in your laboratory; neighboring laboratories, department, or non laboratory areas (garages, paint shops, art department) might be able to use them
45. When solvent is used for cleaning purposes use contaminated solvent for initial cleaning and fresh solvent for final cleaning
46. Try using detergent and hot water for cleaning of parts instead of using solvents
47. Consider using ozone treatment for cleaning parts
48. Consider purchasing a vapor degreaser vacuum bake or a bead blaster for cleaning parts
49. Use the smallest container possible for dripping or for holding photographic chemicals
50. Store and reuse developer in photo labs
51. Precipitate silver out of photographic solutions for reclamation
52. Neutralize corrosive wastes that don't contain metals at the laboratory bench
53. Deactivate highly reactive chemicals in the hood
54. Evaluate the possibility of redistillation of waste solvents in your laboratory
55. Evaluate other wastes for reclamation in your laboratory
56. Scale down experiments producing hazardous waste whenever possible
57. In teaching laboratories, consider the use of microscale experiments
58. In teaching laboratories, use demonstrations or video presentations as a substitute for some student experiments that generate chemical waste
59. Use pre-weighed or pre-measured reagent packets for introductory teaching laboratories where waste generation is high
60. Include waste management as part of the pre and post laboratory written student experience
61. Encourage orderly and tidy behavior in the laboratory
62. Polymerize epoxy waste to a safe solid
63. Consider using solid phase extractions for organics
64. Put your hexane through the rotavap for reuse
65. Destroy ethidium bromide using household bleach
66. Run mini gels instead of full size slabs
67. Treat sulfur and phosphorus wastes with bleach before disposal
68. Treat organolithium waste with water or ethanol
69. Collect metallic mercury for reclamation
70. Investigate possibility for recovering mercury from mercury containing solutions
71. Recover silver from silver chloride residue waste, and gold from gold solutions
72. When testing experimental products for private companies, limit donations to the amount needed for research
73. Return excess pesticides to the distributor

74. Be wary of chemical donations from outside the University; accept chemicals only if you will use them within 12 months
75. Replace or dispose of items containing polychlorinated biphenyls

## Appendix B: Some Tips to Reduce Waste on Campus

From: Environmental Protection Agency, "Business Guide for Reducing Solid Waste," 1993. p.28.  
(<http://www.epa.gov/epawaste/nonhaz/municipal/pubs/red2.pdf> )

### Staff/Faculty Ideas:

- make double-sided copies
- use intercampus mail envelopes
- reuse envelopes sent to you, like the big manila ones
- omit the cover sheet when using the fax; write information on the first page or use one of those small fax post-its
- keep mailing lists current
- make scratch pads from used paper
- circulate memos, documents, periodicals, and reports instead of making individual copies for everyone
- use electronic mail memos or a quick phone call in lieu of written memos
- avoid printing e-mail messages; instead store them on your computer until you no longer need them; (use the multiple print per page function on some computers)
- post messages on electronic mail
- use department bulletin boards to reach the entire faculty and staff using fewer printed copies (great when you need graphics or want to reach employees without computers)
- save documents on hard drives instead of making paper copies (keep backups!)
- use spell check and print preview functions
- proof documents on the computer screen before printing
- use the back side of old paper to print necessary drafts
- use outdated letterhead for memos within the department
- return unneeded information, brochures, catalogs, etc. This will let the department, person, or company reuse the material. (This action is simplified on campus where postage is free and the envelope can be reused!)
- eliminate unnecessary reports
- use rechargeables wherever practical
- avoid ordering excess supplies that may never be used
- use a dry-erase board or chalk board
- make only as many copies as you will need to avoid recycling unused memos, posters, and brochures
- use First Class to have students submit papers electronically

### Departmental Ideas:

- rent equipment that is only used occasionally
- install reusable filters
- purchase remanufactured office equipment
- use the materials exchange on the gopher
- order merchandise in bulk
- purchase concentrates and products with minimal packaging
- return cardboard boxes to manufacturers
- request minimal and/or recyclable packaging
- reclaim reusable parts from old equipment
- choose a landscape design that needs low maintenance
- reuse worn out tires for landscaping, swings, etc.

- find creative uses for waste, like experiments and class projects

Institutional Ideas:

- adopt a company wide double-sided copying policy
- make it more economical for departments to make double-sided copies than single-sided
- negotiate take-back policies with suppliers whenever possible
- reuse packaging materials
- operate a Free Store where materials can be exchanged year round instead of running one office supply exchange per year
- use send and return envelopes for phone/tuition bills, loan payments, Annual Fund solicitations, etc.

## **Appendix C: Household Recycling and Disposal**

For your household, there are avenues to recycle and dispose of any hazardous items. Your municipality should offer recycling for all of your household glass, plastic, metals, paper, etc. For household hazardous items the Pennsylvania Resource Council (PRC) conducts periodic Household Chemical Collections. This group will collect items such as chemicals products, auto maintenance products, home improvement supplies (paints, oil, insecticides, etc), hobby products (glues, paints, cements, etc), pharmaceuticals (nail polish, hair color, prescription drugs, mercury thermometers, etc), or lawn care products. To find out more information check out their website at <http://prc.org/programs/collection-events/household-chemicals/> .