Environmental Management

Training Guide: Green Laboratory Compliance

Unit 1
Compulsory Introduction
Environmental Compliance, Energy and Water Conservation

Designed to inform staff and students working in UNSW laboratories of environmental compliance risks and regulatory responsibilities as well as energy and water conservation best practice.

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Unit 1: Compulsory Introductory Unit

UNSW Green Lab: Environmental compliance induction training designed for Deans, Heads of School, laboratory managers, laboratory staff and researchers including post graduate research students, who have responsibilities in the *UNSW Environmental Law Register*[1].

The training provides an overview of environmental regulatory regime and accountabilities associated with work in UNSW laboratories. It also informs learners of the energy and water conservation best practice.

Another target is to inform learners on how to find and document information from the necessary regulatory resources. These resources include Environmental Law Register for UNSW Laboratories[2], UNSW Environmental Compliance Register[3], Environmental Aspects and Impacts register[4], UNSW policies and procedures, and various laboratory Standards.

Familiarity with these sources of information will improve the professional knowledge of learners and allow them to continue learning and applying their acquired knowledge long after they have completed this induction training.

This induction training complements UNSW Health and Safety training, avoids unnecessary duplication of information already addressed in relevant UNSW Health and Safety training courses.

It is important to note that this program is only targeted at achieving compliance with the environmental regulatory framework, energy and water conservation best practices and chemicals management.

[1] A copy of 'UNSW Environmental Law Compliance Register' for UNSW laboratories is available from http://sustainability.unsw.edu.au/resources
[2] A copy of "Environmental compliance Register for UNSW labs" is available from http://sustainability.unsw.edu.au/resources
[3] Same as no 1
[4] A copy of "UNSW Labs: Environmental Aspects and Impacts Register" is available from http://sustainability.unsw.edu.au/resources

Training Overview

This training program has two basic units.

1. Compulsory Introductory Unit. (Environmental compliance and energy and water conservation).
2. Chemicals Management (Optional unit, required only if working with chemicals)

Learners must successfully complete the introductory unit before moving on to the Chemicals Management unit. Pass mark for the compulsory introductory unit is 90%, and for chemical management its 80%. Quiz assessments for both units are open book and un-timed with no limitation on attempts. Learners should notionally allow 30-40 minutes for completion of the compulsory unit 1 including self assessment activities and the quiz.

An overview of the components of the training program is provided in the diagram below.

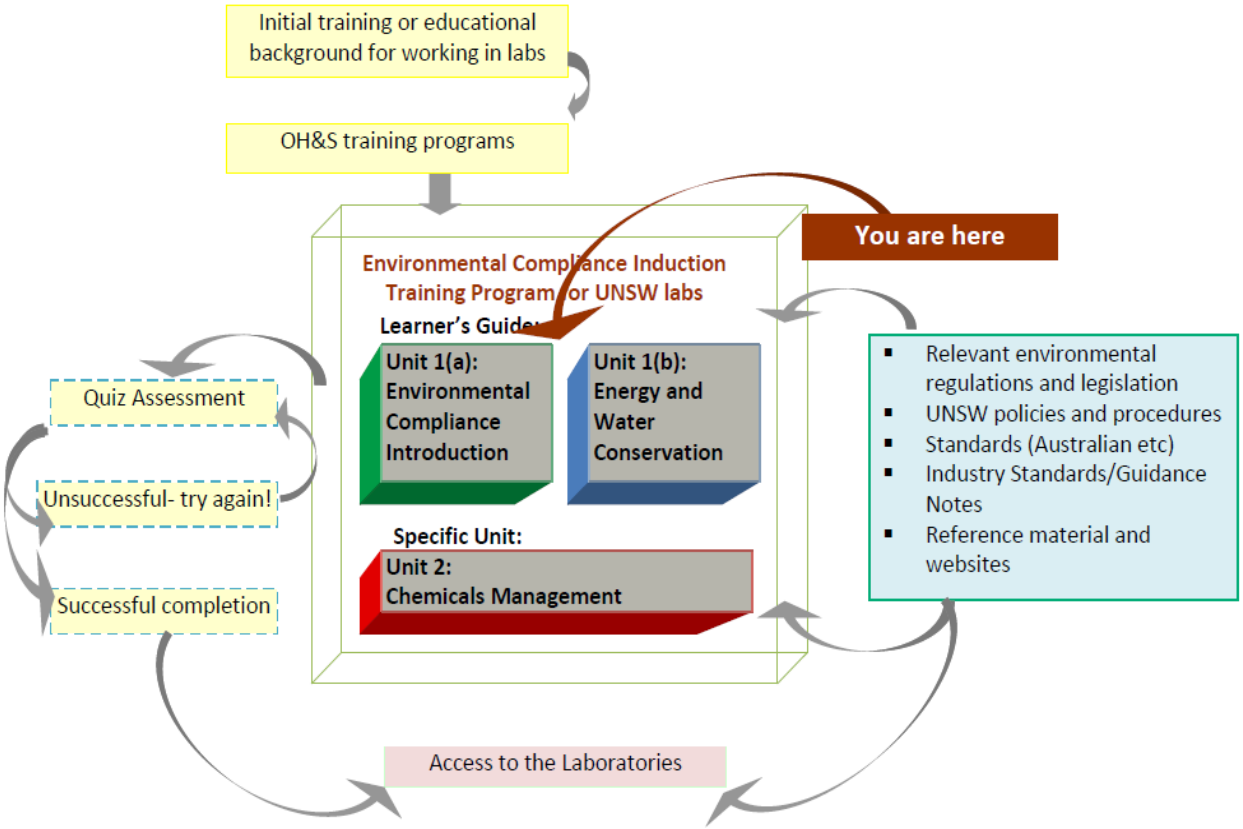


Fig 1: Compliance Induction Training Program – An Overview

Learning Outcomes

Learning outcomes: Compulsory Introductory Unit

After completing this unit you should be able to:

- Identify and document corporate and personal liabilities applicable to breaches that are prescribed in relevant environmental laws and regulations.
- Identify relevant Australian Standards and other guidelines or Standards that are prescribed in applicable environmental laws and regulations relevant to general laboratory management, energy and water conservation at UNSW laboratories.
- Identify relevant UNSW policies and procedures, and document requirements for compliance in relation to general laboratory management, energy and water conservation in laboratories.
- Identify and determine energy and water conservation practices for implementation in UNSW laboratories.
- Identify and select best operational practices for maximum energy and water conservation while working in UNSW laboratories.
- Identify and determine most energy and water efficient equipment selection and installation options for UNSW laboratories.

Introduction to Environmental Compliance

1 Introduction to Environmental Compliance

1.1 Accountability and Penalties

Compliance with relevant laws and regulations is the basic concern for all facilities dealing with dangerous goods and hazardous chemicals. Under the *Protection of the Environment Operations Act individuals face personal fines of up to $1M, and corporations face fines of up to $5M* for breaches of requirements specified in the act. These fundamental requirements are documented in this learner's guide. UNSW has corporate compliance responsibilities, but laboratory users (staff, researchers and managers) also have direct legal personal accountability for awareness of and compliance with the law. Heads of School, laboratory managers and laboratory staff must address and actively support compliance with relevant laws and regulations to avoid incurring personal liability.

This section provides a brief overview of the laws and regulations, standards and other codes of practice applicable to laboratories on campus.

1.1.1 Mandatory Compliance: Acts and Regulations

Acts and Regulations are the most important aspect of the regulatory framework. Compliance with Acts and Regulations is mandatory under the laws of NSW (Fig 2). There is a long list of laws and regulations applicable to specific activities of laboratories at UNSW. These laws and regulations will be dealt within the specific units (e.g. chemicals management). This introductory unit discusses only those laws which generally define and outline the accountabilities and penalties in relation to laboratory practices.

The main NSW environmental laws and regulations which outline accountabilities and penalties for general laboratory management are:

- Protection of the Environment Operations Act 1997,
- Protection of the Environment Operations (General) Reg 2009,
- Protection of the Environment Operations (Waste) Reg 2014,
- Waste Avoidance and Resource Recovery Act 2007,
- Environmentally Hazardous Chemicals Act 1985,
- Occupational Health and Safety Act,
- Occupational Health and Safety Regulation 2016.

Of these, the NSW Protection of the Environment Operations Act and related regulations are the most significant regulatory documents which define and outline accountabilities and penalties in relation to "*environmental pollution and harm to environment*".

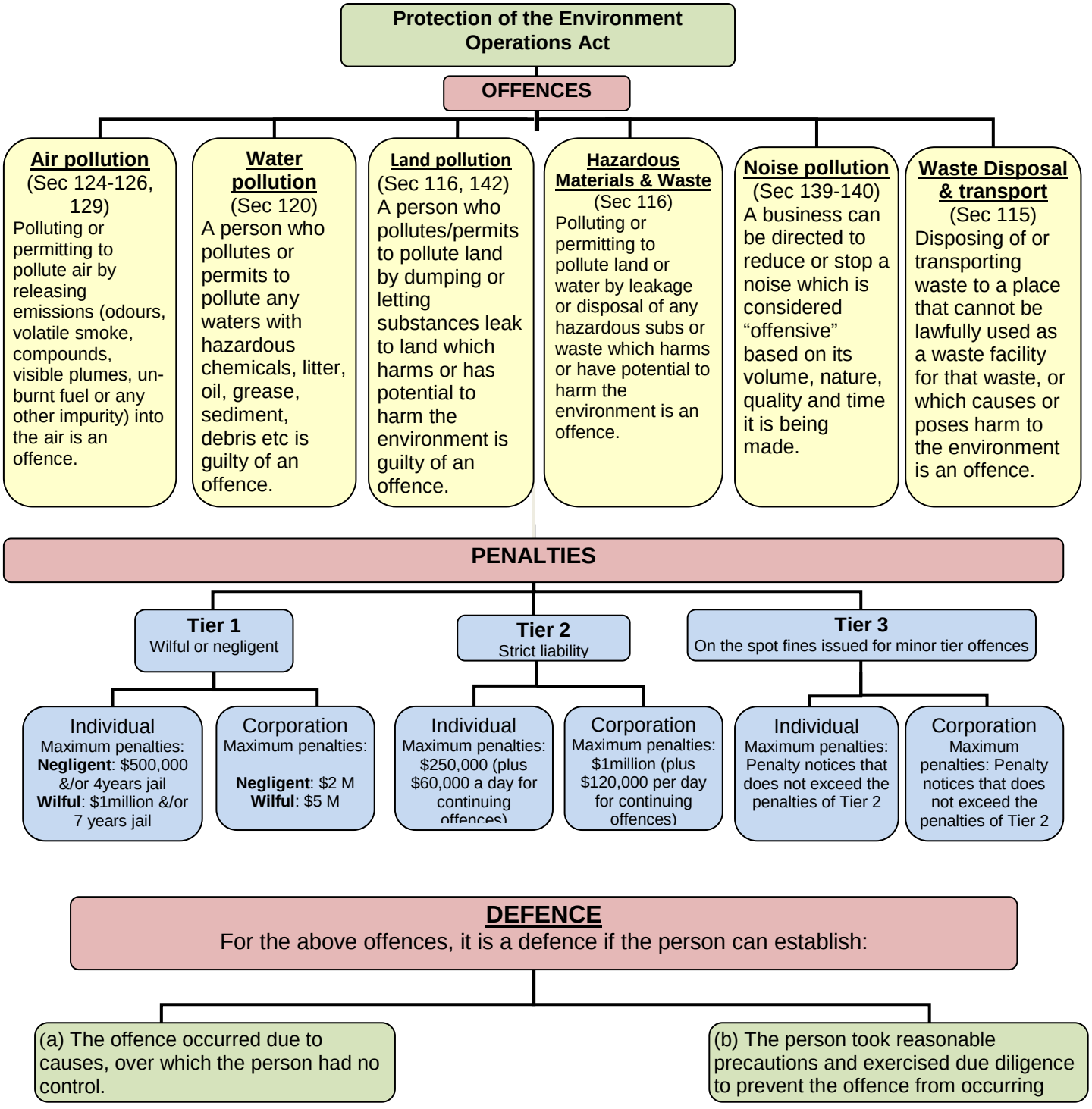
For further consultation and details a complete version of the Act and Regulations can be accessed from http://www.legislation.nsw.gov.au/.

What types of pollution comes under Protection of the Environment Operations Act 1997?

- Air pollution
- Land pollution
- Noise pollution
- Water pollution
- Waste transport and disposal

1.1.2 Protection of the Environment Operations Act

NSW Protection of the Environment Operations Act and Regulation are the key regulatory tools for managing local and broader environmental impacts.



1.1.3 Best Practice Guidance Material

In addition to the mandatory Acts and Regulations, there is a long list of relevant guidance material which is generally not mandatory unless the document is called up by an Act or a Regulation.

Conformance with accepted Codes and with Australian Standards can be used as evidence in a court of law to demonstrate that operational practices are appropriate. Compliance is desirable unless another solution or precaution achieves an equal or better outcome (Risk and Reliability 2004).

UNSW Policies and Procedures are derived from the mandatory compliance sources. If an incident or breach occurs, the strongest defence against potential personal liability is demonstrable compliance with UNSW guidelines, general industry standards and procedures.

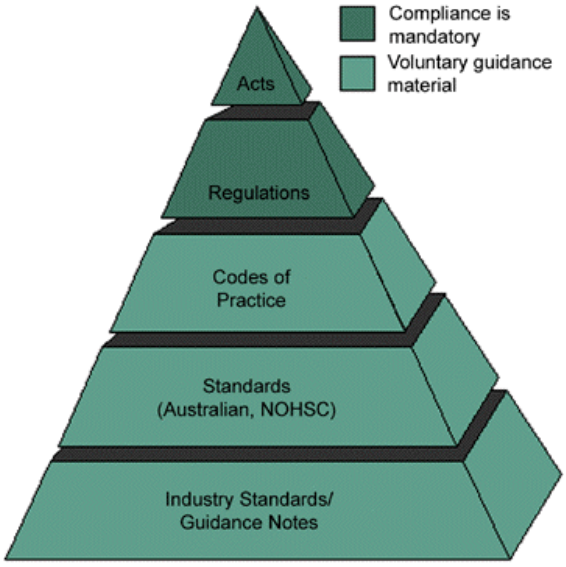


Fig 2: Legal Framework (Risk and Reliability 2004)

Lists of the relevant UNSW Policies and Procedures, Codes of Practice, Australian Standards, and other industry Standards and guidance notes are provided in the appendix 7.1 and 7.2. In addition, your school and/or specific laboratory should have a documented laboratory manual and procedures. Please note that UNSW staff and students can access the Australian Standards available from SAI Global through UNSW Library portal.

Exercise 1: accountabilities and penalties

Take 2 minutes to find correct answers for these questions. You should be able to find relevant information in the above sections.

- If a person negligently disposes of waste in a manner that harms or is likely to harm the environment, can he/she be held personally accountable in a court of law?
- What is the maximum penalty for an individual person, who pollutes, causes, or permits pollution of any waters (Tier 2 offence)?
- Can conformance with Australian Standards be used as defence in a court of law?

Key Learning Points

Good work! You have completed the information about basic compliance framework and regulatory regime. You should now have an understanding of

- The major Environmental Laws and Regulations which outline the accountabilities and penalties.
- The level of penalties for breaches of these Laws and Regulations.
- The relevant UNSW Policies, Procedures and Australian Standards for Laboratories.

1.2 Laboratory Management

This section outlines the environmental compliance requirements and best practice relevant to lab management at UNSW. Mandatory compliance issues are directly dictated by law and must be cautiously managed to avoid risk of penalties (fines and/or imprisonment), as discussed in the previous section.

1.2.1 Mandatory Compliance

To avoid possible penalties laboratory managers/other staff/students must make sure that the following mandatory compliance requirements are fulfilled.

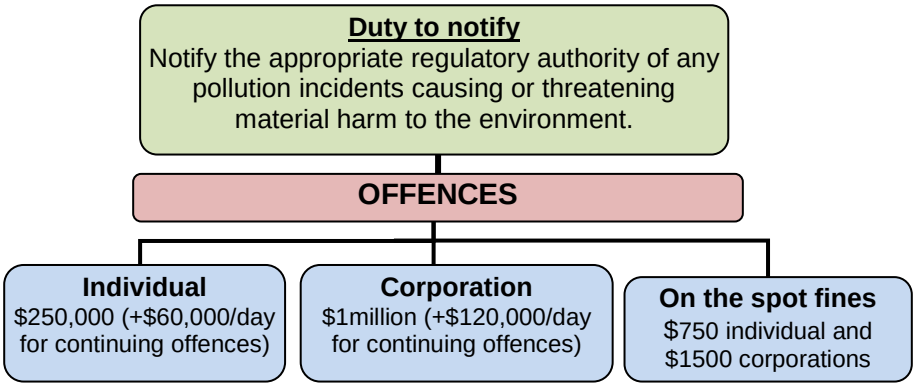
What is a "Pollution incident"? Protection of the Environment Operations Act defines pollution as an incident or set of circumstances during or as a consequence of which there is or is likely to be a leak, spill or other escape or deposit of a substance, as a result of which pollution has occurred, is occurring or is likely to occur.

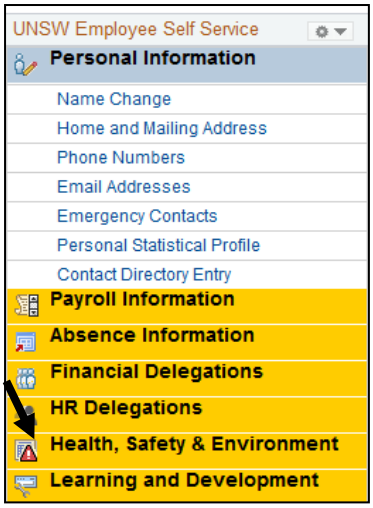
2.2.1.1 Maintenance (Hazardous waste disposal)

- It is mandatory to have hazardous waste management (chemical, radiological, biological) plans and procedures in place in all laboratories at UNSW. All laboratory users must be aware of such procedures and must follow such procedures completely because negligent or wilful disposal of waste in a manner which is hazardous to the environment is a Tier 1 offence under the Protection of Environment Operations Act. Please read the case study of *Warringah Golf Course Verdict*[5] provided in the Key Resources module of the Compliance Induction Training Program.
- Under the Protection of Environment Operations Act (Pollution of Water Tier 2 offences Sect 120) and Sydney Water Corporation Commercial Trade Wastewater Permit, disposal of any hazardous chemical or dangerous good down the drain[6] or to the storm water system at UNSW **is prohibited**.
- Leaks, spillage and other escapes of hazardous chemicals to the environment are also considered as Tier 1 offences under the Protection of Environment Operations Act (SECT 116). A person who causes, or contributes to this situation is considered liable. It is vital for laboratory managers and users to put effective measures in place for preventing any such incident, and to action these measures.
- Under section 148 of the Protection of the Environment Operations Act, everyone has a duty to notify a pollution incident. Any pollution incident causing or threatening material harm to the environment must be notified.

Don't let this be YOU!
Warringah Verdict:
On September 30, 2003 New South Wales Land and Environment Court (LEC) imposed fines and costs approaching $600,000 against the **Warringah Golf Club** after finding it negligent for its role in a pesticide spill which lead to a major ecological disaster in the Manly Lagoon in 2001. LEC also sentenced former Warringah superintendent Craig Coggins to 250 hours of community service and ordered him to pay costs of up to $50,000 for his part in the incident which killed 4.16 tonnes of marine and bird life.

[5] The Warringah verdict case study (Australian Golf Course Superintendents Association 2004) is available in the "Key Resources" link in the Green Lab Training.
[6] Drain linked directly to sewerage system





- Hazard and/or risk identification and reporting plays a vital role in environmental management. On identification of a potential hazard or risk to the environment inform your manager or lab supervisor immediately. Log a hazard/incident report through online Health, Safety & Environmental reporting system available through MyUNSW. For further details and how to report guides go to Health and Safety website. In case of emergency call security at **x56666**.

2.2.1.2 Emergency

- All UNSW community members (Staff, students, contractors, visitors etc) and general public have a duty to notify the appropriate regulatory authority of any pollution incidents causing or threatening material harm to the environment.
- Every laboratory user must be well aware of the mandatory requirements and procedures for notification of a pollution incident that has harmed or can harm environment. All lab users are under legal obligation to report all pollution incidents to the authorities. Call **emergency at x56666** immediately and inform lab supervisor or manager. If in doubt call NSW EPA 24hour pollution line **131555**. Log a hazard/incident report through online Health, Safety & Environmental reporting system available via MyUNSW.
- It is mandatory to have a suitable spill kit available to deal with spill of any substance stored within the laboratory.
- Any emergency situation in a laboratory can result in serious danger to the immediate and wider environment. Developing, maintaining, implementing and communicating an effective emergency plan is mandatory for every laboratory at UNSW.
- All emergency contacts, chemical storage maps, and chemical inventory must be updated and accessible to every laboratory user.

What is "material harm to environment"???
According to Protection of the Environment Operations Act material harm is:
(1) Actual or potential harm to the health or safety of human beings or to ecosystems that is not trivial,
OR
(2) Actual or potential loss or property damage amounting to $10,000, including on your own premises.

- Under OH&S Amendment (DG) Reg 2005 (P6A. Div3, Sub Div 3 &10) all laboratories and dangerous goods storage and handling facilities must be secure and lockable to avoid accidents, unauthorised access and security breaches.
- All doors and emergency exits of a laboratory must be accessible with proper signage. Warning placards should be placed in internal locations and on external wall of the building (AS/NZS 2243.2.5.4: 2005).
- A fire safety plan and procedure is vital for a laboratory dealing with any kind of dangerous goods. It is mandatory to have an appropriately designed Fire Protection System and complimentary procedures.

Exercise 2: Mandatory Compliance

Take 2 minutes to find correct answers for these questions. You should be able to find relevant information in the above section.

- What must you do if you come across a potential hazard or risk in your laboratory?
- What is the emergency number at UNSW?
- Which of the emergency plans/requirements identified in above section are implemented in your lab?

Key Learning Points

Good work! You have completed the section about compliance framework and requirements for working in labs at UNSW. You should now have an understanding of:

- Appropriate disposal of hazardous chemicals
- Appropriate system for dealing with leakages and spills
- Importance of emergency procedures, systems and prominent display of information, signs in your laboratory

1.2.2 Best Practice

Best practice guidelines (standards, policies, procedures etc) are not mandatory requirements but can still be used in a court of law as a defence through demonstrating compliance with appropriate practices. The following best practice guidelines are mainly based on Australian Standards and UNSW procedures and guidelines for laboratories. Please note that these guidelines are aimed at environmental compliance and best practice only, and complement other OH&S requirements and practices.

In case of a pollution incident compliance with best practice guidelines (Standards, policies, procedures, trainings etc) can be used as defence in court of law.

2.2.2.1 Maintenance

- Before creating new experiments and procedures all relevant staff and students should be well aware of the applicable environmental laws and regulations applicable to their work.
- Before starting an experiment or procedure the types and expected amounts of wastes generated should be documented. All staff and students should be trained in handling and disposing of the expected types of waste properly before starting the procedures.
- All laboratory users should be aware of the location and use of Material Safety Data Sheets (MSDS), safety attire, safety procedures and emergency numbers (NOHSC:2011, AS/NZS 2243.1:2005).
- A copy of hazards and incidents reports should be available in all laboratories for reference and record keeping.
- A copy of the laboratory manual should be posted on the wall near the laboratory entrance to ensure easy access to the document for all lab users.
- All floor drains[7] should be covered to avoid hazardous materials discharge to the sewerage system.
- All dangerous goods and hazardous materials should be securely stored and all cabinets should be locked.
- Hazardous chemicals and dangerous goods should be stored in a manner that they do not obstruct doors or emergency exits.
- The laboratory should have adequate lighting in accordance with relevant Australian standards to minimise the risk of accidents and injury (AS 1680).
- The use of electrical extension cords should be avoided. If necessary, power leads should be secure and properly installed.
- No food or drink should be allowed in laboratories and “No food or drink” signs should be posted at prominent places in all laboratories.
- Emergency procedures, contact details and first aid guidelines should be visibly displayed in the laboratory.
- Material Safety Data Sheets (MSDS), safety attire and a copy of the safety procedures should be stored in a prominent and readily accessible location.
- Waste minimization should be an inherent part of the waste management procedures. All hazardous or general waste generation should be minimized and waste must be disposed of properly and according to UNSW policies and procedures.

[7] Leading to sewerage or storm water system

- "Reduce, reuse and recycle" methodology should be applied to all materials used in laboratories (e.g. chemicals, dangerous goods, furniture, e-waste, paper, water). Following are details of some reuse/recycling program at UNSW:
  - All paper and cardboard used in UNSW can be recycled by placing them in the paper recycling blue bins.
  - Mobile phones and batteries (up to D size) can be recycled at UNSW. For details visit http://sustainability.unsw.edu.au/environment/recycling-and-waste .
  - UNSW Stationery Reuse Centre is managed by Arc. Go to http://www.arc.unsw.edu.au/grow/volunteering/stationery-reuse-centre for further details.
  - Furniture reuse program: Facilities Management has established an online furniture reuse program. For further information go to http://www.facilities.unsw.edu.au/staff-contractors/furniture-reuse-program .

- All laboratory users should use appropriate Personal Protective Clothing and Equipment (PPCE) while working in laboratories at all times (AS/NZS 2243.1.4.2:2005) This includes laboratory clothing, protective eyewear, gloves, closed shoes, hearing protection (if required), additional or specialised personal protective clothing and equipment (e.g. respirators).

2.2.2.2 Training

- All laboratory users should complete all relevant induction trainings (HSE, Green lab environmental compliance, general induction, work and site specific training) before accessing laboratories.
- All laboratory users should be properly trained to understand the types of pollutants prohibited from discharge to sewer.
- All laboratory users should be aware of waste management procedures, including segregation of waste, appropriate disposal, documentation and storage, and general waste disposal. (Guidelines, procedures, forms and relevant information for hazardous waste are available at https://safety.unsw.edu.au/procedures-forms).
- Waste minimization strategies should be an inherent part of training and should be discussed before waste management and handling issues.
- Laboratory users should be well aware of the potential impacts of their work on the environment and should be encouraged in the planning stage to minimise and manage risks.
- Training sessions, and discussions (e.g. informal environmental risk discussion with laboratory managers or environment unit professionals) should be conducted annually and all laboratory users should be encouraged to participate each year to reinforce knowledge of requirements.

2.2.2.3 Emergency

- All staff/students should be aware of the emergency procedures in the event of a chemical/ pathological/ radioactive exposure, spill, fire or explosion. At UNSW, first response is to contact UNSW emergency number "***56666***" (UNSW internal number) or "***9385 6666***" (external).
- The spill kit present in the laboratory should be large enough to deal with the largest single volume of material stored (e.g. 20L drum).
- The spill kit should contain all materials required for handling chemicals present in the laboratory (neutralizing agents for acid and base spills, inert material for oxidising liquids, etc).

- There should be regular contact between laboratory management and emergency services (AS/NZS 2243.2.5.6: 2006).
- The evacuation plan, spill procedures, safety phrases, and emergency contacts should be prominently displayed on the laboratory wall to make sure that in time of need it is accessible to everyone (AS/NZS 2243.4 and 2243.5).
- All accidents in laboratories, even minor ones, should be reported in accordance with the UNSW policy. At least one copy of each report should be kept in the laboratory along with MSDS's and other documents in an accessible place.
- All laboratories should have at least a dry chemical fire extinguisher and it should be regularly checked (AS/NZS 2243.2.6: 2006).
- In case of a spill stop all work immediately and try to contain the spill using materials from the spill kit. After containing the spill inform the lab supervisor or manager and then clean up thoroughly according to the relevant procedures. All spills should get reported to the lab supervisor or manager.

Exercise 3: Best Practice

Take 2 minutes to find correct answers for these questions. You should be able to find relevant information in the above section.

- What is the emergency response phone number at UNSW?
- In addition to work, health and safety related training, what other induction training is required by UNSW for all laboratory users?
- What sort of information should be displayed in a laboratory in a prominent place?

Key Learning Points

Good work! You have completed the section about best practice while working in UNSW labs. You should know now that your lab must have:

- Appropriate signs and placards displayed prominently
- Induction training for lab users, including introduction to waste management procedures, emergency contacts and plans
- An appropriate spill kit
- An evacuation plan, spill procedures and emergency contacts

Energy and Water Conservation

2 Energy Conservation

This part of the compulsory introductory unit details best management practice guidelines for energy and water conservation in UNSW laboratories. UNSW Australia is a large user of energy and water with annual costs in the order of $11 million for energy and $1.25 million for water. UNSW Energy management office maintains an Energy and Water Strategy. This strategy documents UNSW commitment to energy and water saving and identify implementation of the energy and water conservation as a priority for environmental compliance induction training for UNSW laboratories.

For economic and environmental reasons, UNSW places a high value on energy conservation, and the use of on-site renewable energy sources. Laboratories, especially research laboratories, are thought to consume somewhere between five to ten times more energy per square metre than typical commercial buildings (Harris 2003). This tremendous energy demand has made labs a major focus of energy conserving efforts at UNSW.

The following best practice guidelines are based on Australian Standards, NOHSC and UNSW procedures and guidelines for laboratories. Please note that these guidelines target improved environmental performance, and complement other Health and Safety requirements and practices.

2.1 Fume cupboards

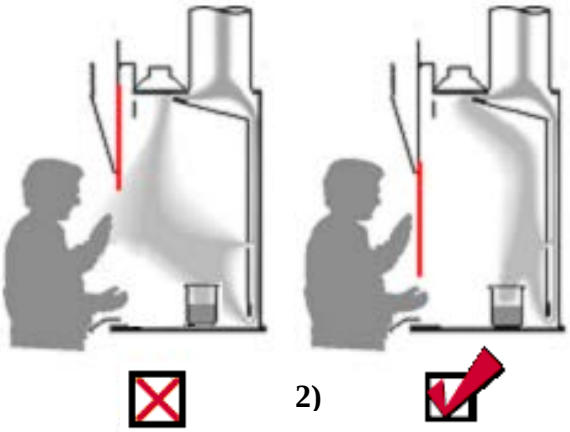
Fume cupboards typically have the largest energy use in a laboratory which is under the control of the occupants. A single fume cupboard may use more energy in a year than three typical residential dwellings. Fume cupboards use energy directly through exhaust fans, flow monitors, fume cupboard lighting, and other mechanical devices. They also use a great deal of energy indirectly because they exhaust a lot of air that has been heated or cooled (conditioned air).

“The most important activity to be performed by lab occupants for safety and energy conservation purposes is keeping the fume-hood sash closed when not in use, particularly when the laboratory is unoccupied.” Rios (1999)

Following guidelines and practices help containment of fumes and dramatically reduce losses of indoor heated or cool air through fume cupboard resulting in massive energy savings.

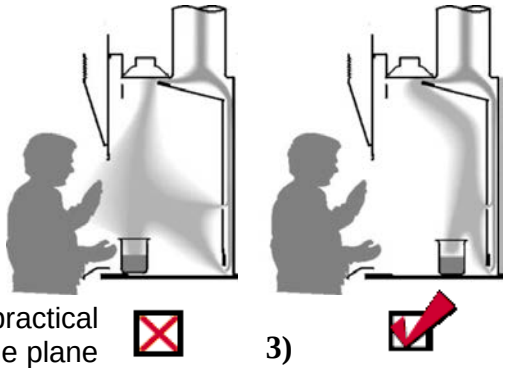
2.1.1 Operational practices

- The fume cupboard sash should always be lowered as much as possible especially if you are using a fully ventilating fume cupboard. This increases safety for users whilst ensuring effective ventilation, and dramatically reduces the loss of conditioned air and lowers the workload on fume cupboard exhaust fans. A typical hood costs $5000[8] per year in heating/cooling energy costs. Closing a sash can cut the air volume and cost by two thirds. Raise the sash to full open position only for set-up purposes (See figure 2- Harris et al 2008).



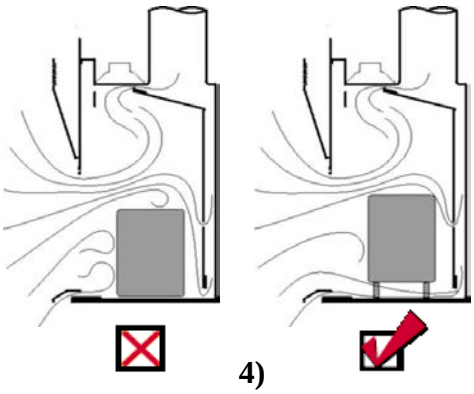
2)

- Excessive equipment and apparatus in the hood should be avoided. As a rule of thumb, no more than 50% of the work surface should be covered by equipment, apparatus or other bulky obstruction. Equipment should never extend beyond the plane of the sash or restricted the sash from closing. This ensures effective ventilation without excessive burden on the exhaust fans.



3)

- Always locate equipment as deep into the hood as practical and at least six to eight inches (15 to 20 cm) beyond the plane of the sash. (see figure 3- Harris et al 2008)
- Elevate equipment two to three inches (50 to 75mm) above the work surface to provide flow beneath and around the equipment. This ensures an effective and safe air flow.(see figure 4- Harris et al 2008)
- Do not store any equipment that restricts the closing of the sash. An open sash means wastage of massive amounts of energy and increased risk to lab users from fumes.
- Ensure your head and upper body remains outside the fume cupboard.
- Open and close the sash slowly. Similarly approach and withdraw from the hood slowly.
- Avoid rapid withdrawal of equipment/items from the fume cupboard.



4)

2.1.2 Equipment/infrastructure selection and installation

- A “circulatory fume cupboard” uses 40% less energy than full ventilating fume cupboards and is useful for less hazardous work. All lab managers and users should identify potential for replacing full ventilating fume cupboards with circulatory fume cupboards where practical for the range of laboratory activities practiced.
- Fume cupboard sashes should ideally have alarms, either visible, such as flashing lights, or audible, that activate whenever the sash has been raised for an extended period of time.

[8] US dollars – figure taken from a study conducted in Duke University by Harris et al 2008

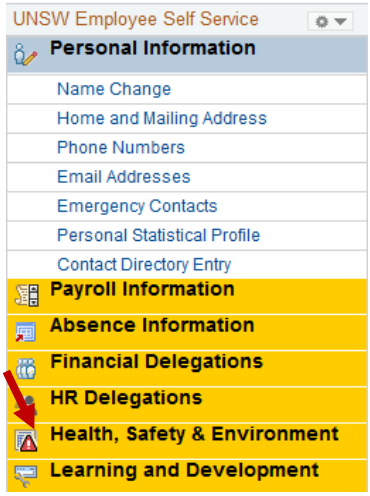
2.2 Heating Ventilating and Air Conditioning (HVAC)

More than 60 percent of the energy consumed by a conventional lab or clean-room is used to filter, condition and circulate air so energy-efficient designs and practices can result in substantial savings (Labs for the 21st Century 2006).

2.2.1 Operational practices

The type of air conditioning system and controls installed in a laboratory may limit the operating temperatures that can be adopted and the ease with which the set-points can be changed for any given case. The notes below provide some general advice on settings.

- There is plenty of evidence that people will remain comfortable, can perform light duty work tasks well, apparatus can hold their calibration, computers and other electronic equipment will provide reliable service at a temperature of 24ºC ±1ºC. Unless there is a critical equipment or experimental need, laboratories thermostats should be set to this target in summer. Lowering the set point 1ºC from this target can increase energy consumption by 10% for really no practical benefit. During winter, or the heating period of the year, normally June to August, thermostats should be reset to 20ºC ±1ºC. This may mean recalibrating some apparatus, but again energy savings are considerable (compared with leaving the settings at 24ºC). People and equipment can function well at this temperature.
- Setting heating, ventilation and air conditioning (HVAC) to this temperature range (20ºC winters to 24ºC summers) provides thermal comfort for people in the room without unnecessary energy use required to maintain increased heating or cooling. All labs, if not required otherwise for specific research purposes, should not have their HVAC system set lower or higher then these thermal comfort benchmarks at UNSW.



- Promptly report abnormal room comfort conditions. Inform lab manager/supervisor or call FM Assist on "***938***55111" Rooms that are too hot or too cool may be due to faulty thermostats or other controls that are malfunctioning or have drifted from set-points resulting in wasted energy as well as uncomfortable conditions for you.
- Log a hazard/incident report through Online Environmental and HS reporting system available through MyUNSW.
- Ensure that only those parts of the building that really need it are being heated/cooled, rather than the building as a whole
- Ensure that buildings are being heated/cooled only when there is someone there or stable conditions are essential for experiments. Unnecessary use of HVAC system can result in considerable waste of energy.
- In general, thermostats are set to the guidelines values. Where possible secure, lock or otherwise prevent ready access to A/C temperature controls so that set points once established are not altered by just anyone that has access to the laboratory. Everyone has a personal comfort zone. Occupants should adjust to the ambient temperature by wearing clothing appropriate to the season and not by ad-hoc manipulation of A/C temperature controls.
- Provide direct cooling of equipment (e.g. using chilled water) where possible, rather than using air cooling.

- Ensure good integration of heating and cooling systems, i.e. eliminate conditions that cause simultaneous heating and cooling loads, so systems aren't fighting each other because over-cooling results in the heating coming on and vice versa
- Select energy efficient components such as compressors, fans, fume cupboards etc
- Where possible group equipment which create a high heat load, such as fridges and freezers, in separate areas to reduce the space needed for cooling. If this equipment is grouped and carefully located then the heat it generates can often be disposed off via mechanical ventilation rather than an A/C system, thereby saving energy.

2.2.2 Equipment/infrastructure selection and installation

- Identify and investigate opportunities for replacement of central air conditioning systems with smaller individual units for heating and cooling. The use of small units means they can be operated independently and this enables the central A/C service to be only supplied where and when needed. In some cases this can save energy compared with using a large central system that serves a building with laboratories.
- Some laboratories may need once-through air conditioning, that is, they bring in outside air, use it once and then exhaust the air without returning any of it to the air handling unit. Such systems are used where 100% fresh air is needed to avoid odour problems (e.g. animal handling areas) or for other amenity or HS reasons. Normal A/C systems use less than 20% outside or fresh air so using 100% outside air usually means high energy use. This can be mitigated by installing energy recovery systems. These can recover or transfer up to 75% of the heating or cooling service to the incoming air stream. Wherever A/C systems are using high levels of outside air, use of energy recovery should be considered.
- Install A/C on/off controls with a time on limit, or request a time clock control with on-off times closely tailored to actual occupancy times. In the latter case regularly review the time clock settings in the light of any changes to laboratory scheduling. .
- Lab manager should identify opportunities for installation of new energy efficient cooling/heating equipment (e.g. instantaneous gas heating) in consultation with the FM Energy Manager.
- Lab managers should identify opportunities for using timers that will turn equipment off after a set period, rather than just leaving the equipment on continuously.
- Correctly size laboratory equipment. Over-capacity equipment adds unnecessarily to A/C loads. Over design has a severe effect on energy consumption. Future proofing, or building in large margins, wastes capital and can lead to inefficient A/C installations. Large A/C chillers operate poorly at low loads, and may even fail.

2.3 Other Lab Equipment Energy Use and Conservation

The following energy conservation strategies should be adopted in all UNSW laboratories.

2.3.1 Operational practices

- Potential environmental impacts of any work in a laboratory should be assessed before starting experiments, preferably at the point of experimental design.
- Experiments should be engineered in such a way that the smallest possible amount of energy is required. Select small quantities of materials used so that smaller equipment is used resulting in minimum use of energy.

- The least resource consuming and polluting methods should be used for cleaning glassware. When using a dishwasher always use a full load. Lab users should identify opportunities for sharing glass washing equipment wherever and whenever possible.
- Turn off all unnecessary/unused electrical equipment whenever possible, and when you leave for the day.
- Autoclave units are one of the large energy using items of equipment in laboratories at UNSW. To reduce energy use, with these units always use a full load, as with dishwashers. Identify opportunities for sharing autoclave units among laboratories or schools. It is highly recommended to have a central autoclave unit for a school or at least a building level to maximise energy and water saving.
- Lights should only be on when required. Occupancy sensor or task lighting should be used in labs in UNSW.
- All laboratories on campus should have a policy and relevant signs reminding occupants to turn off lights and equipment.
- Computers should be set to hibernate and not to screen savers as screen savers don't allow the computer go in to energy saving mode. Ask suppliers to enable this energy saving features as the standard setting prior to delivery.
- Turn off your computer's monitor when not in use. The monitor consumes over half of the energy used by the average computer. Even if you can't turn it off, always set your computer's energy savings features to put your computer and monitor "to sleep" after 10 minutes which cuts power use nearly to zero. Ask suppliers to enable these energy saving features as the standard setting prior to delivery.
- Lighting, also a major energy user and additionally adds to A/C loads. During the day, and where glare is not an issue, turn lights off and open blinds to make the most of daylight. Consider putting the perimeter lighting under the control of a photovoltaic cell so that it is turned off automatically when outside light is high. Ask for high efficiency background lighting (like CFL or LED) but do not over specify the lux or light levels; instead use laboratory workbench based task lighting to achieve higher levels where necessary.
- For building services or to report faulty fixtures call FM assist on "***93855111".***

2.3.2 Equipment/infrastructure selection, installation and disposal

- Apply energy efficiency as selection criteria when purchasing equipment and buy energy efficient equipment. Look for the Energy Star logo or other statements that an electrical device is designed to be energy efficient. Extra cost of a "high efficiency unit" can be paid for in 5-7 years or less due to savings on energy bills. All electrical equipment should be at least 4 star rated (autoclaves, dishwasher, refrigerators, freezers, ovens, vacuums). Where laboratory equipment is not subject to the energy star labelling, suppliers can provide information on energy consumption and energy savings mode features upon request.
- At UNSW all old halogen light bulbs are required to be changed with energy efficient lights, this program is centrally funded and lab manager should consult the FM Energy Manager.

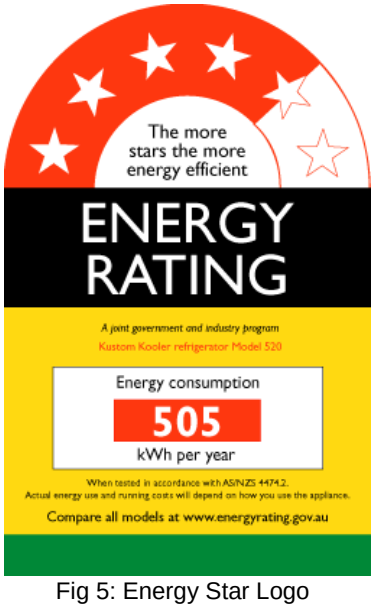


Fig 5: Energy Star Logo

- Computers and printers should have energy star ratings.
- Use shades and blinds as provided to help keep your space cool on sunny days. The shade can reduce your peak A/C energy consumption by over 30%
- UNSW has programs in place for reuse, recycling and environmental friendly disposal of following equipment and material:
    - E-Waste: UNSW has a few options for E-Waste reuse/recycling on campus. Contact e-Reuse centre to donate unwanted laptops or good desktops. To recycle your e-waste (computers, monitors, key boards, printers etc) contact FM Assist 93855111 or email sustainability@unsw.edu.au for further information.
    - Batteries: UNSW Sustainability runs a domestic battery recycling collection service for UNSW staff and students. Collection bins are located in FM Assist and ARC reception. For further information check the link.
    - Mobile Phones: UNSW Sustainability provides a mobile phone recycling collection service for UNSW staff and students. Collection bins are located in FM Assist and ARC reception. For further information check the link.
    - Printer Toner Cartridges: there are more than 80 collection boxes for recycling printer toner cartridges throughout UNSW. For further information check the link.
    - Fluorescent and other lights: For proper disposal of fluorescent lights, CFL, incandescent, halogen and discharge light bulbs/lamps and associated ballasts and transformers, High Intensity Discharge lamps (HIDs) and metal halide; contact FM assist on 93855111.

Exercise 1: Energy Conservation

Take 2 minutes to find correct answers for these questions. You should be able to find relevant information in the above section.

- Which of the high energy consuming items identified in the above section are installed in your lab?
- What are the ways to reduce energy consumption of fume cupboards?
- What is the thermal comfort setting for A/C adopted at UNSW?
- What is the number at UNSW to report faulty fixtures and building services?

Key Learning Points

Good work! You have completed the information about basic compliance framework and regulatory regime. You should now have an understanding of

- Always keep the fume cupboard sash as low as possible.
- Never leave the sash open when fume cupboard is not in use.
- Always keep the fume cupboard tidy- never store equipment or chemicals in the fume cupboard.
- Always follow the best operational practices to ensure maximum energy conservation while working in UNSW laboratories.
- Follow the most energy efficient equipment selection and installation options for UNSW laboratories.
- Follow procedures to avoid accidents and emergency situations which can result in harm to property and environment.

3 Water Conservation

The UNSW Energy and Water Strategy highlights management of water, by conservation and careful monitoring and reporting to track trends and promoting staff and student awareness of water issues on campus.

Pollution of any waters is a Tier 2 offence under the NSW Protection of the Environment Operations Act 1997. To ensure compliance with environmental laws and "Sydney Water Trade Waste Agreement," no chemicals or waste material is allowed to reach any water system at UNSW. These issues are discussed further in Unit 2: Chemicals Management.

3.1 Autoclave and Sterilizers

Autoclave units are one of the large water using equipment in laboratories at UNSW. Following are the guidelines to reduce water use in autoclave units and sterilization equipment:

3.1.1 Operational practices

To make autoclaves and sterilizers more efficient:

- Use autoclave only when it is full.
- Identify opportunities for sharing autoclave units among laboratories or schools. It is highly recommended to have a central autoclave unit for a school or at least a building level to maximise water and energy saving.
- Shut off units that are not in use, or install an automatic shut-off feature if it does not interfere with the unit's normal operation.
- Use high-quality steam where available for improved efficiency.
- Consider the feasibility of using uncontaminated, noncontact steam condensate and cooling water as make-up for non-potable uses, such as in cooling towers and boilers.

3.1.2 Equipment/infrastructure selection and installation

- Purchase new equipment only if it is designed to recirculate water or allows the flow to be turned off when the unit is not in use, or both.
- Adjust flow rates to the minimum values recommended by the manufacturer, and review and readjust them periodically.
- Install a small expansion tank instead of using water to cool steam for discharge to the sewer. Check with the manufacturer to make sure this will not interfere with the unit's normal operation.
- Consider purchasing a water conservation retrofit kit; many are now available for older units. They reduce water use by either controlling the flow of tempering water or by replacing the venturi mechanism for drawing a vacuum. Tempering kits sense the discharge water temperature and allow tempering water to flow only as needed. This can save about ≅11000 litres per day when equipment is in idle mode. Venturi kits replace the venturi with a vacuum pump, saving approximately 90 gallons per cycle (Labs for 21st Century 2005 pp6).

3.2 Other Lab Equipment Water Use and Conservation

The following water conservation strategies should be adopted in all UNSW laboratories. These strategies are directly derived from the relevant Codes, Australian Standards and UNSW policies and procedures and can result in large savings in water in laboratories.

3.2.1 Operational practices

- Identify any opportunities for conserving water in your lab.
- Potential environmental impacts of any work in a laboratory should be assessed before starting experiments, preferably at the point of experimental design.
- Experiments should be engineered in such a way that the smallest possible amount of water is required. Select small quantities of materials used so that smaller equipment is used resulting in minimum use of water.
- Supply of cooling water to bench-top aspirators and cooling coils is one of the most water wasting of all laboratory activities (approx 38kL per day). Managers/supervisors should exercise tighter controls on use as well as identify opportunities for more water efficient methods.
- Reverse osmosis and de-ionized water are identified as one of the most water consuming activities in UNSW labs (approx 26kL per day). Managers/supervisors should exercise tighter controls on use as well as identify opportunities for more efficient RO units (also see appendix 7.1).
- Circulated cooling water is identified as one of the top water consuming activities in UNSW laboratories. In the distant past, laboratory cooling water was used once and then discharged to the sink. Needless to say this is not an efficient use of water. At UNSW, laboratory cooling is setup with supply and return lines. Where the return lines does not automatically return chilled water to the system laboratory managers/operators should ensure that chilled water (ex-apparatus or straight from the supply) is not dumped down a sink but is correctly discharged to the “return tundish” (bench drain) or other dedicated return point.

Fig 6: Bench-top Tundish

- Water aspirators may use up to 22 litres/minute (Rutgers 2005). In a research laboratory these aspirators can be used continuously up to 8 hours a day. In addition to water consumption there is always a potential risk of contamination of waste water from organic solvents from the fumes which are carried from the flask through aerators. Only use water aspirators when absolutely necessary. As the opportunity arises, and only as an interim measure, replace old aspirators with new water efficient models, which may only use 6 litres/min. An even better solution is to make a complete conversion to a full mechanical vacuum system.
- For some experiments chilled water is required to provide apparatus or process cooling. Under no circumstances should the building’s primary closed circuit chilled water loop be tapped into to provide this service. This loop may be used to cool a laboratory chilled water system via a heat exchanger, which means no water is drained from the primary system.
- Input of clean/potable water and output of waste water should be minimized, especially when there is a chance of contamination of water with volatile solvents and other chemicals.

- When preparing a new procedure or protocol, the types and quantities of waste products should be evaluated, and possible methods to reduce or eliminate liquid waste should be considered.
- Least resource consuming and greener methods should be used for cleaning glassware. When using a dishwasher occupants should identify opportunities for sharing glass washing equipment where possible. Further, to reduce the amount of water used by dishwashers:
    - Run dishwashers only when they are full
    - Use newer, cleaner rinsing detergents
    - Reduce the number of rinse cycles whenever possible
- Keep in touch with other labs and lab users who are using similar equipment and procedures. This practice can promote sharing of equipment, material and experiences which can result in savings.
- Early detection and repair of faulty fixtures can result in large water savings. Please report leaking taps or associated fixture faults immediately to FM Assist on *93855111.*
- Underground pipe work leaks are estimated to be in the order of 10% of total consumption of water at UNSW. Please report all pipe leaks and fixture faults to FM assist on *93855111*.
- Employ technologies/methodologies based on Pollution Prevention hierarchy – reduce, reuse, recycle.
- Apply segregation – especially in baths – so that materials are separated from process water. This also recovers materials and thereby reduces overall material use.
- Work with scientists and researchers to modify process as to reduce water use wherever possible without compromising the experiment or research objective.
- All staff/students should be aware of the emergency procedures in the event of a chemical/ pathological/ radioactive exposure, spill, water emergency, fire or explosion. At UNSW, first response is to contact UNSW emergency number 56666 (UNSW internal number) or 9385 6666 (external). Log a hazard/incident report through Online Environmental and HS reporting system available through MyUNSW.

Fig 7: Typical repair- leaking evaporative cooler

Fig 8: Water Star Rating Logo

3.1.1 Equipment/infrastructure selection and installation

- All water using equipment should have a high water star rating (dishwasher, autoclaves, fixtures etc). Lab managers should ensure that all new water-related equipment and fixtures are minimum 4 star water efficiency rated.
- Lab managers should identify opportunities for replacement of water aspirators with mechanical vacuum systems to limit use of aspirators in laboratories.

- Replace inefficient reverse osmosis water treatment unit with a modern unit. This practice can substantially reduce reject water from 60% to 30% of the average water supplied to the unit.
- Identify opportunities for redirection of Reverse Osmosis reject water to cooling tower make-up tanks in consultation with.
- Always install circulated supply and return cooling water infrastructure to prevent cooling water going to waste.
- Identify opportunities for replacement of manual taps with timed flow taps or foot or knee operated self closing taps.
- Identify opportunities for installation of general water saving devices: e.g. timed flow taps, waterless or water saving urinals and dual flush cisterns.
- UNSW policy is to provide all new ablution basins with time flow taps. New laboratory basins are provided with special hands-free tap ware, which operate at 4L/min. Old installations are gradually being retrofitted with in-line devices restricting flow to 4L/min or restricting duration of flow using timed flow taps. Lab managers should contact FM to identify opportunities for replacing old basins and taps in their labs.
- Treat process wastewater so that is can be down-cycled for use in cooling towers, etc.

Exercise 2: Water Conservation

Take 2 minutes to find correct answers for these questions. You should be able to find relevant information in the above section.

- Which of the high water consumption items identified in above section are installed in your lab?
- How can you reduce the water consumption of a dishwasher?
- Where should you report leaking taps and pipes at UNSW?
- At UNSW what should be done in case of a water emergency?

Key Learning Points

Good work! You have completed the information about basic compliance framework and regulatory regime. You should now have an understanding of

- Always follow the best operational practices to ensure maximum water conservation while working in UNSW laboratories.
- Follow the most water efficient equipment selection and installation options for UNSW laboratories.
- Follow procedures to avoid accidents and emergency situations which can result in harm to property and environment.

4 Assessment

Assessment

You have completed the compulsory introductory unit. Please have a go at the quiz assessment.

- Click on the assessment link. Please read guidelines before attempting.
- It is a quiz assessment with ten multiple choice questions chosen from a random pool. You have unlimited access to the quiz but you cannot save and go back to an incomplete attempt. In every new attempt you have to start a new quiz. Pass mark for unit 1 is 90%.
- After successful completion of unit 1 quiz, unit 2 Chemicals management will appear on the menu. Once both assessments are completed successfully your records will automatically update on MyUNSW.
- If you are not required to complete unit 2, please contact administrator of your school for exemption or email greenlab@unsw.edu.au .
- For any further assistance or inquiries please go to the "frequently asked questions" link in the module or email greenlab@unsw.edu.au

5 Useful Websites and links

The following web links and documents are highly useful for laboratory users at UNSW. It is recommended that you take a few minutes to explore these links and documents.

- Policy@UNSW: links and information related to latest UNSW policies Environmental Compliance Register for UNSW Laboratories[9]
- Laws and regulations: NSW laws and regulations link
- Sustainability on campus: links and information related to energy and water management on campus
- Energy and Water Strategy : links and information related to energy and water management on campus
- HS forms and checklists: UNSW HS procedures, forms, checklists etc.
- Incident and hazard reporting: Reporting procedures and forms
- Health and Safety procedures and forms
- Indoor Thermal Comfort Review Procedure
- Indoor Thermal Comfort Guidelines For Managers
- Green Chemical Alternatives Purchasing Wizard

[9] A copy of 'Environmental Compliance Register for UNSW laboratories' is available in the 'key resources' organiser link, present with other unit links on the training program main page.

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7 Appendix

7.1 Relevant Standards

- AS/NZS 1270 Acoustics – hearing protectors
- AS/NZS 1336 Recommended practices for occupation eye protection
- AS/NZS 1715 Selection, use and maintenance of respiratory protective devices
- AS/NZS 2161 Occupation protective gloves
- AS/NZS 2210 Occupation protective footwear
- AS/NZS 2243 Safety in laboratories
- AS/NZS 2243.1:2005 Safety in Laboratories Part1: Planning and operational aspects
- AS/NZS 2243.2:2006 Safety in Laboratories Part2: Chemical aspects
- AS/NZS 2243.6:1990 Safety in Laboratories Part 6: Mechanical aspects
- AS/NZS 2243.7:1991 Safety in Laboratories Part 7: Electrical Aspects
- AS/NZS 2243.8:2006 Safety in Laboratories Part 8: Fume Cupboards
- HB 9 Occupational Personal Protection
- National Code of Practice for the control of workplace hazardous substances [NOHSC:2007(1994)]

Replacement options for lab equipment and fittings

Following table provides considerations for selection of replacement of laboratory equipment and fittings for energy and water efficiency. Please note that these equipment replacements options are general in nature. Lab managers are recommended to act with additional consideration of the particular site arrangements, circumstances, and research requirements before replacing any equipment.

- Also check Energy Efficient Laboratory Equipment

GENERAL TIP: Before selecting any lab equipment check for:
Energy efficient equipment; end of life take back program; mercury free; reusable products and products with reduced or recyclable packaging.

Equipment Type	E&W Efficient Replacement Option
Fume cupboards	Circulatory fume cupboards (instead of Ventilating fume cupboard)
Bulbs/lighting	Compact fluorescent energy saver bulbs (instead of incandescent/halogen bulbs)
Old Reverse Osmosis water treatment units	Modern more efficient RO plants
Water aspirators	Mechanical vacuum where possible
Incubators	Look for auto-off, timer with alarm, door-ajar alarm, less than 100W at maximum heating/cooling.
Bio-Safety cabinets	Look for efficient motor; night smart mode idles blower when sash fully closed; efficient, timed lighting; efficient air delivery;
Centrifuges	Select the one with variable speed and “brushless” motor
Dri-baths	Anodized aluminium block for maximum heat transfer
Ovens	Select the one with forced convection heating; auto shut-off; high density mineral wool insulation.
Vacuum pumps	Select the one with optional pneumatic control energy saving system; energy efficient motor; low level of waste heat.
Mixers and shakers	Variable speed control; optional covers to prevent heat loss and minimize evaporation.
Other (fridge, freezers etc)	Select the more energy efficient model. Check different suppliers for the best deal.
Linear cooling water system	Circulatory cooling water system
Computer	With higher energy star rating and energy saver settings

Legal Disclaimer

This package assumes that learners have already completed the relevant HS training courses conducted by the HS and Workers Compensation unit in UNSW Human Resources http://www.hr.unsw.edu.au/ohswc/ohswc_home.html

This induction training program has been developed by UNSW Sustainability. It directly complements UNSW H&S training and avoids unnecessary duplication of information already addressed in relevant UNSW H&S training courses.

This module exclusively addresses additional requirements for compliance with environmental aspects of directly relevant acts and regulations that apply in NSW at time of writing. The information contained in this document is essentially general and incomplete in nature and is not advice that can be directly applied to any specific situation or context without reference to additional, site specific information.

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