Washington Clean Energy Testbeds

User Manual

15 August 2020

Introduction

The Washington Clean Energy Testbeds (WCET) is a multi-location facility with individual testbeds in the Bowman Building and the Nanoengineering and Sciences Building. This manual is written specifically for the Characterization and Scale-Up and Systems Integration Testbeds, located in the Bowman Building at 4625 Union Bay Place NE, Seattle, just east of the University of Washington (UW) campus.
WCET is an open-access facility for energy systems research, development, scale-up, prototyping, and utility-scale testing. The 14,700 square foot lab represents a major investment in facilities and equipment by UW's Clean Energy Institute (CEI) and is the only energy testing and fabrication facility in the Pacific Northwest. The WCET facilities were designed with the help of major local industrial and research partners and we interface regularly with teams from Washington State University, Pacific Northwest National Laboratory, and a number of companies. As such, we strive to enable rapid advancements in energy science, engineering and technology.

WCET offers a full range of device processing and characterization capabilities, including (but not limited to) solar simulation, battery cyclers, infrared spectrometry, profilometry, scanning-electron microscopy, X-ray diffraction, roll-to-roll printing, screen printing, 3-D printing, processing ovens, real-time digital simulation, and battery storage hardware.

Our user base spans academia, local start-ups, established businesses, and professional organizations, with the goal of promoting local economic and job growth in the energy sector by fostering the transition of innovative technologies from the laboratory into the market. Additionally, WCET staff scientists and engineers provide contracted services through which fabrication and characterization can be performed for customers both in the US and internationally. University researchers and industry clients are active in a wide range of applications and research areas, including:

- Novel Photovoltaics
- Batteries and Energy Storage Systems
- Building Controls
- Grid Management, Control, and Simulation
- Prototyping and Scaled Manufacturing
- Thin-Film Coating and Printing
- Integrated (Bio)Electronics
- Flexible Energy Harvesting and Storage
- Utility-Scale Technology Testing and Verification

WCET has two sister facilities on the UW campus through the CEI: Molecular Analysis Facility (MAF), located in the Molecular Engineering and Sciences Building, and the Washington Nanofabrication Facility (WNF), located in Fluke Hall. Both facilities house complementary leading-edge instruments for nano-scale fabrication and characterization. Please refer to their respective websites for full equipment capabilities, tools and contact information:

MAF: http://www.moles.washington.edu/maf/

WNF: https://www.wnf.washington.edu/

General Information

WEBSITE AND CONTACTS

Up-to-date contacts, news, and information about WCET can be found at our website, wcet.washington.edu. The website has links to information regarding starting a project, staff contact information, and downloadable forms (User Agreement, current rates, grant support, etc.).

USING THE FACILITY

Users are classified as either UW (internal students, faculty, staff, or business unit with a UW budget number) or external (non-UW). External users are further categorized as academic/non-profit (other academic institutions, government organizations, and non-profit organizations) or non-academic/industry (for-profit, industrial companies). As a user facility, the most common paradigm is for individuals to process their devices in person (onsite users). An alternative approach is to contract facility staff to perform limited scope characterization studies and/or fabrication processes (remote users).

Users are classified as either UW (internal students, faculty, staff, or business unit with a UW budget number), Non-profit (Researchers employed by or with appointments at non-UW academic institutions, government organizations, or other non-profit organizations) and industry (any employees of non-academic and non-government organizations). As a user facility, the most common paradigm is for individuals to process their devices in person (onsite users). An alternative approach is contract facility staff to perform limited scope characterization studies and/or fabrication processes (remote users).

ONSITE USERS

While working at WCET, you will learn a variety of processes and gain valuable skills. After a lab orientation and general use training, you will sign up for equipment training as needed. We advise finding a mentor or consulting with staff to ensure proper laboratory technique and etiquette.

REMOTE USERS

WCET staff scientists and engineers are available to conduct limited-scope work on a best effort, time and materials basis for remote users. Due to the experimental nature of most contract processes, we cannot provide product or data guarantees, but will work closely with clients to determine project feasibility, provide cost estimates, and attempt to obtain mutually satisfactory results.

BECOMING A USER

Before becoming a user, we suggest scheduling a meeting with staff to discuss your project and, optionally, to see the facility. Next, you will need to complete the registration process on the new user site at:

https://www.coral.washington.edu/tomcat/CORAL//WCET.html?mode=register

This website will direct you through the induction process. In short, the process involves determining your role (UW or external, remote, etc.), and then entering contact and billing information and a project proposal. After reading and understanding this User Manual, you must complete and return the appropriate Facility Use Agreement, either UW or Non-UW. Optionally, you can complete a Non-

Disclosure Agreement (NDA). Lastly, you will also be required to complete a variety of online and in person training, explained in more detail on the website.

REPORTS AND ACKNOWLEDGEMENTS

Occasionally, WCET staff may request input in compiling publication lists and highlighting research in our labs. Additionally, you are required to acknowledge work conducted at the WCET in your publications and presentations. A suggested acknowledgment is: “Part of this work was conducted at the Washington Clean Energy Testbeds, a facility operated by the University of Washington Clean Energy Institute.” Your cooperation in response to these requests is mandated by your signed user agreement and greatly appreciated.

BILLING

WCET is a non-profit business unit within the University of Washington that charges time and materials on a cost reimbursement basis with monthly invoices. Academic pricing is achieved through UW and state grants and subsidies. External rates are set for cost recovery. Rates are a function of cost of operation (labor and materials) and utilization.

Users of the WCET are eligible to use MAF and WNF facilities under a single purchase order but will receive a separate monthly invoice from each facility.

Due to the nature of work at the facility, it is not possible to issue binding quotations for projects. Many projects have unanticipated changes in scope and processes based on experimental results, so a “not to exceed” purchase order is recommended to account for possible changes with minimum logistical overhead.

CONSULTING

Staff engineers are readily available for Critical Design Reviews (CDRs). These consulting sessions are a venue to discuss project concepts, process flows, or specific technical issues. Current or potential users are encouraged to hold discussions with staff on a regular basis to work through processes and to troubleshoot problems. Independent CDRs can be scheduled as needed by contacting the lab director or engineering staff.

USER AND STAFF MEETINGS

Each research group and/or project client group will be required to appoint a representative to the WCET user committee. Representatives can be professionals, professors, post-doctoral researchers or graduate students, but they should be regular users of the WCET facilities and familiar with typical day-to-day operations. In other words, principal investigators that are not regularly at the Bowman building are encouraged to appoint another researcher to the committee.

The user committee will meet weekly to discuss all issues pertaining to WCET, including concerns over instrumentation, staff relations, building infrastructure and other aspects. User representatives are expected to attend all committee meetings and must discuss alternative options with WCET management if they are unable to attend. WCET staff meetings will occur no more than 24 hours after the user committee meets – ideally immediately after – to ensure that user concerns are addressed as quickly as possible.

INTELLECTUAL PROPERTY AND SECURITY

While working at WCET, there will be no restrictions on your intellectual property (IP) or entanglement thereof with the University of Washington. Many clients execute an NDA in order to protect their IP (use of the UW pre-approved form will expedite the NDA process).

Occasionally staff will engage in collaborative development campaigns with users. In these cases, general processing techniques that are not IP-specific may be shared with the general user base, but applications and full process flows will not be shared unless given explicit permission.

Facility Information

SPACE DESIGNATIONS

OFFICES

Offices are located on the second floor and the south side of the first floor corridor in the Bowman Building. Office provisions are made on a discretionary, as-available basis by the director. Private offices are made available primarily for heavy onsite, full-time users, but are not guaranteed. Users who do not require a private office – or heavy users waiting for a private office to become available – may apply for designated desk space or hot seats in shared offices.

SYSTEMS INTEGRATION TESTBED FACILITIES

Bowman Rooms 100, 107, and 108 provide access to Systems Integration testbed facilities. The Campus Energy Control Center is located in Room 108 and houses computer consoles that provide users with virtual access to Hardware-in-the-Loop (HitL), Real Time Digital Simulation (RTDS) capabilities, smart meter data, and UW solar installations on the campus grid. Room 107 houses the RTDS hardware, Room 100 houses the HitL equipment. Unless otherwise authorized, users are not permitted in the HitL room unless accompanied by WCET staff members.

CHARACTERIZATION AND SCALE-UP TESTBED FACILITIES

The Characterization and Scale-Up Testbed is located in Rooms 110-113. In addition to UW standard laboratory policies that apply to all campus laboratories, each of the four rooms have specific rules for contamination control and safety. Users must be trained on conditions of access and specific, relevant instrumentation to enter the Characterization and Scale-Up Testbed Facilities.

EQUIPMENT CAPABILITIES

A complete and updated equipment list can be found on the website at http://depts.washington.edu/wcet/about/instrumentation/. Equipment is separated into the following categories:

- Fabricate – Controlled environment room, gloveboxes, centrifuge, Mars6 microwave reactor, Standard Oven, Thinky Planetary Mixer, BlueM Process Oven, Annealsys Rapid Thermal Processor, UV Ozone Cleaner, Vacum Oven, Flow Reactor, MTI Coin Cell Press, Qsonica Probe Sonicator, Col-Int Tech Box Furnace, Ball Mill, Large Scale Reaction Vessel, Bath Sonicator,

Formlabs 3D Printer, Ultimaker 3D Printer, nScrypt 3D Printer, SIJ-050 Ink Jet Printer, Dimatix Ink Jet Printer, Laurell Spin Coater, Nanonex Nano Imprint Lithographer.

- Scale – FOM Roll-to-Roll Printer, Xenon Flash Cure Lamp, SIJ-150 Ink Jet Printer, New Long Screen Printer, FOM R&D Sheet Coater, FOM Mini Roll Coater, Bent River Vacuum Laminator.
- Test – Kruss Drop Shape Analyzer, Anton Paar Dynamic Light Scatterer, Anton Paar Rheometer, Maccor Series 4200M 16-Channel Battery Test System, Maccor Series 4000 96-Channel Battery Test System, Arbin 5V/60A Battery Tester, Arbin 60V/50A Battery Tester, Arbin HPTC-2104 High Precision Coulombic Efficiency Tester, Ametek Versastat 4, Ametek Parstat 4000A, Spire Flash Tester, OAI Solar Simulator, PV Measurements QE, Tenney Environmental Test Chamber, Russels Environmental Test Chamber, Nikon Digital Microscope, Bruker DekTak Profilometer, Olympus OLS-4100 Optical Profilometer, Phenom ProX SEM, Mettler-Toledo TGA/DSC and DSC, Micromeritics BET, Thermonicolet FTIR, Agilent UV-Visible Spectrometer, Bruker X-Ray Diffractometer, Oxford Instruments Asylum Research Jupiter XR AFM.
- Integrate – Powin Battery, OpalRT Control Room, Keithley Battery Emulators, Keysight PV Emulators, PLECS Power Electronics Simulator.

General Laboratory Policies and Procedures

PRIORITIES

1. Safety. You are responsible for your safety and for those around you. Do not work in the facility when you are tired, sick, medicated, or intoxicated. Read and understand the safety information in this manual, equipment protocols, and safety data sheets.

2. Facility and Equipment Integrity. Never compromise the equipment or facilities for your research. Understand and abide by equipment restrictions. If you damage or contaminate equipment while straying from equipment protocols, you will be liable for property and equipment damages that may include staff time, spare parts, vendor services, or equipment replacement.

3. Your Research.

CODE OF CONDUCT

Assume responsibility for the lab. Always follow safety, equipment, and cleanliness protocols, even if your work is not sensitive to contamination or particulates. Never leave a mess; if you find one, either clean it or notify staff. Report equipment problems and notify staff and other users if you have made a mistake or may have caused contamination. Share space and respect equipment reservations. Ask questions if you are unsure. The lab operates effectively when everyone is cordial, follows instructions, and communicates.

LABORATORY ITEM AND ACTIVITY RESTRICTIONS

The following table lists items and activities that are restricted in all laboratory spaces. This is not an exhaustive list; be sure to ask if you have questions.

Partial List of Prohibited Items/Activities	Allowed Items/Activities
Food or drink, gum, cough drops, mints, etc.	Cell Phones/Headsets
Smoking	Cameras
Backpacks	Laptops, PDAs, e-readers, music players
Jackets/Coats	Notebooks
Offensive or obscene materials or media	

VISITORS

Visitors are not allowed in the Bowman Building beyond the lobby space without approval. If you want to bring visitors beyond the lobby, you must submit an online Visitor Request Form to wcet@uw.edu at least two days before the visit. An active WCET user must escort each visitor during his or her entire time in laboratory spaces and is responsible for the visitor's actions and safety. Visitors are to abide by all safety measures expected of laboratory users and are not allowed to operate any laboratory equipment or perform any chemical operations. Visitors are not allowed in the facility after normal hours or as buddies to meet the buddy system requirement. Visitor Request Forms are available by request or on the website.

DRESS CODE

The WCET dress code applies to all laboratory areas. It is based on industry-wide best practices for working in areas containing hazardous materials and preventing undue dust production from human sources. You will be denied access to laboratory spaces if you are not dressed according to the following rules.

HYGIENE

You and your clothing should be clean (i.e. free of dust or dirt) before entering lab spaces. Avoid clothing that sheds fibers such as wool, fur, fake fur, mohair, etc. Dirty or shedding clothes contaminate everyone's work. Make-up and cosmetics are not allowed in lab spaces.

SHOES

You must wear shoes that completely enclose the heel, toes, and top of your feet. Socks or stockings are required. Sandals, open-weave shoes, or shoes that expose the top of the foot are not allowed. High heels and deep-treaded shoes that hold mud or dirt are also not allowed. Despite the substantial wet weather in the Pacific Northwest, your shoes should be clean and dry before entering the labs. It is preferable that you bring a clean, dry change of dedicated lab shoes that you do not wear outside.

PANTS

You must wear long pants that run from your shirt to your ankles. Athletic leggings/yoga pants, shorts, short pants, capris, ripped pants, skirts and dresses are not allowed. You may bring with you a pair of lightweight hospital- scrub style pants to wear over your shorts or athletic leggings.

SHIRTS

Your shirt must cover your shoulders and reach from the top of your arms to your pants. Tank tops, halter-tops, and spaghetti strap tops are not acceptable.

SAFETY GLASSES

Safety glasses must be worn at all times in all labs. The WCET provides safety glasses, or you may choose to purchase your own glasses, provided that they meet ANSI Z87.1-2003 standards. Safety glasses are not acceptable for chemical protection; face shields are available for those working with large (>100 mL) volumes of chemicals. In some cases, further eye protection may be required for specific circumstances. Please refer to the Personal Protective Equipment (PPE) section for details in chemical protection protocols.

CONTACT LENSES

Consistent with recent recommendations from the American Chemical Society, contact lenses are allowed in WCET laboratories, provided that safety glasses are also worn at all times. In the case of an eye exposure emergency, rinse at the emergency eyewash station with contacts in place and remove them while flushing.

More specific and detailed information about Personal Protective Equipment (PPE) is provided during the initial Lab Orientation and listed below.

CORAL

CORAL (Common Object Representation for Advanced Laboratories), originally built by Stanford and MIT, and extended here at the UW, is software used to measure and control the use of user facilities. WCET uses UW CORAL Web Front End, an interface layer that allows users (and administrators) to use the UW CORAL installation without having to install any application on their computer (or mobile device). The interface is usable for basic tasks on a mobile device, though some functionality requires a desktop or laptop computer. The key features of UW CORAL are listed below:

- User Registration
- Instrument Restrictions
- Instrument Scheduling
- Instrument Problem Reporting
- Use Monitoring
- Review and Corrections
- Billing and Reporting

You will be given a short introduction to CORAL in your general orientation. Additional information is located at http://coral.engr.washington.edu/doco/.

EQUIPMENT POLICIES

RULES

- You must be trained and officially qualified before using any equipment.
- Do not use equipment for unapproved purposes.
- Tool owners must authorize all new processes.
- Your reservation will be void if you have not enabled the tool within 15 minutes of your start time.
- You must report equipment problems or damage to staff.
- Do not use equipment that has been enabled by other lab users.
- Disable equipment when you are finished.
- You must submit a billing adjustment request to wcet@uw.edu every time you need staff to adjust your billing. If you require an adjustment because you forgot to disable an instrument, you will be charged a fee.

EMERGENCY MANUAL OFF (EMO)

Most tools have EMO switches that will disable all power to the system and should only be used in emergencies. Using an EMO can be detrimental to equipment, so you should carefully distinguish process instabilities and uncommon runs from emergency situations. If you notice electrical arcing, smell or see smoke, or determine your health is in immediate danger, do not hesitate to use the EMO switch. Flickering plasma, unusual etch rates, or a system that will not pump to the expected vacuum are not emergencies that warrant the use of an EMO.

PERSONAL EFFECTS STORAGE

Lockers are available for storage of all personal items, such as coats, knapsacks, bicycle helmets, books, etc., while working in WCET. These lockers work with a generic code that cannot be reset by the user, so in effect work more like cubbies. The lockers may also be used for storage of personal items while users are away from the Bowman Building for meetings, lunch, etc. Overnight storage is not permitted; items left for prolonged periods may be disposed or reclaimed. Do not bring any of these items into the Characterization and Scale-Up testbed. Do not store chemicals or hazardous substances inside the lockers; ask staff if you need internal lab storage space.

SCALE UP AND CHARACTERIZATION LAB Policies and Procedures

LABORATORY ITEM/ACTIVITY RESTRICTIONS

Many of the activities in the Scale Up and Characterization (SUC) laboratory are sensitive to dust and particulate contamination. While this facility does not contain a clean room, we do restrict certain items and activities to ensure proper laboratory function. The table below lists items that can and cannot be brought into the SUC testbed. Minimize contamination by only bringing items necessary for your research into the laboratory spaces.

Partial List of Prohibited Items/Activities	Allowed Items/Activities
Cardboard, fiberboard	Plastic items, plastic boxes, plastic containers
Books, magazines, etc.	Laboratory notebooks
Pencils, erasers	Pens
Over-the-ear headphones	Ear bud headphones (keep at low volume)
Hats, coats, scarves, bags, backpacks, etc.	Laptops, e-readers, cell phones
Makeup, cosmetics	
Running, Jogging	

GOWNING PROCEDURES

Proper gowning is important to maintain garment and facility cleanliness. Gowning will be demonstrated for you during the initial lab orientation. The SUC is treated as a cleanroom even though it is not technically a cleanroom. You can also see proper technique here:

- Before entering the SUC, make certain you meet the dress code requirements.
- Before entering the SUC, put on a pair of blue shoe covers, a lab coat, and safety glasses.
- After entering the SUC, immediately put on a pair of nitrile gloves from the supply rack.
- Once inside the SUC, do not remove PPE items, except in the case of replacing nitrile gloves.

SCALE UP AND CHARACTERIZATION LAB PROTOCOL

All users must help maintain the integrity, usability, and effectiveness of the cleanroom. Even if your project is not sensitive to particulates or other contamination, you must follow all cleanroom protocols at all times.

- If your gloves are torn, soiled, or otherwise contaminated, immediately remove the them and put on new gloves.
- Never touch common objects with contaminated gloves. Cross contamination can permanently damage equipment and expose other users to chemical hazards.
- Sticky mats are placed throughout the lab to reduce airborne particulates. Do not step over or bypass the sticky mats.
- Do not leave items strewn about the lab. After one week, unclaimed items will be discarded or reclaimed.
- Do not sit or lean on equipment or tables.
- Do not shake hands.
- Use all materials (e.g. wipes and chemicals) sparingly.

GLOVE BOX STORAGE SPACE

Each research group or company can request one glove box shelf section for storage of sensitive samples and necessary lab supplies. This storage is intended for active materials, not archival storage.

You cannot store any items that are incompatible with the atmosphere of the glove box in which your storage space is located. If you need special chemical storage, please make a formal request to the WCET staff by email (wcet@uw.edu).

Working with Chemicals

UNIVERSITY OF WASHINGTON LABORATORY SAFETY MANUAL

WCET is a laboratory space controlled by the University of Washington. As such, we must follow rules outlined in the University of Washington Laboratory Safety Manual put together by Environmental Health and Safety (EH&S). This manual can be found at:
https://www.ehs.washington.edu/system/files/resources/lsm.pdf

You are responsible for understanding this laboratory safety manual and abiding by its rules. Additionally, there are several EH&S online safety courses you must complete to become an internal lab user that are a required part of the online CORAL registration.

UNDERSTANDING HAZARDS

Do not use or handle any chemical until you read and understand its label and safety datasheet (SDS). Understand the hazards, handling, storage, disposal, and emergency procedures for every chemical you use. SDSs are located on the User Information Computer Station in Room 112 and are also available through CORAL. While these are pointed out during the initial lab orientation, you are responsiblefor knowing evacuation routes and locations of eyewashes and shower stations.

GENERAL SAFE PRACTICES

- Do not taste, touch, or smell any chemicals.
- Do not mix, heat, dispose, or otherwise use chemicals in an unauthorized manner.
- Work with chemicals in an exhausted fume hood or wet bench.
- Use chemicals only on wet benches where they are approved.
- Never mix acids and organic solvents.
- Never dispose of chemicals and/or toxic materials down water drains.
- Change your gloves if they might be contaminated.
- Label your chemicals using sticky labels provided by WCET at the user information desk.
- Properly store all chemicals and samples.
- Never add or remove chemicals from the lab without permission.
- Use chemicals and wipes sparingly.
- Bring in only the amount of chemicals you need into the lab.
- Do not interrupt or distract users working with chemicals.
- If you are unsure of handling or safety procedures, ask WCET staff for guidance

BUDDY SYSTEM

All work in the Scale-Up and Characterization lab requires a buddy. Certain particularly hazardous activities require a fully-trained, fully-attentive buddy to be working with you for the duration of that work. Some analysis work, such as using a microscope, is permitted without a buddy; however, it is recommended that you coordinate such lab activities to ensure that at least one other person is in the

vicinity. You can not assume that someone is your buddy if they happen to be in the lab. When using hazardous substances, you must explicitly notify them that you need a buddy, and they must accept that responsibility. Your buddy may not leave until chemical operations are completed and you have cleaned up, unless you are able to identify another buddy.

CHEMICAL CLASSES AND STORAGE

Acids – Acids are substances that donate protons when dissolved in water. Acids are used for etching metal and cleaning wafers, are generally corrosive, and can be toxic or water reactive (e.g. sulfuric acid). Inorganic acids are stored in the appropriate blue corrosives cabinet, while organic acids are kept in the white organics acid cabinet underneath the acid/base fume hood. Nitric acid, however, is an oxidizer and an exception, and must be stored accordingly (see below for oxidizers).

Bases – Bases accept protons, and can increase the hydroxide ion concentration when dissolved in water. Bases are stored in the appropriate blue corrosives cabinet.

Oxidizers – Oxidizers are agents that are easily reduced, and generally supply oxygen to chemical reactions. Oxidizers can react violently with organic chemicals. Oxidizers are stored under the acid/base fume hood.

Solvents – Although the term "solvent" refers to any liquid used to dissolve another material, at WCET "solvents" are typically organic liquids that are flammable or combustible. We use acetone, isopropyl alcohol, ethanol, methanol, n-methyl pyrrolidone, dimethyl sulfoxide, and a variety of others. Solvents are stored in the yellow flammables cabinets near the Room 112 entry vestibule.

NEW MATERIALS REQUESTS

Only WCET laboratory staff can accept new chemicals and materials into the WCET labs. Before bringing a new chemical into the Scale-Up & Characterization Testbed, you must send a completed Materials Request Form, an SDS, and a Standard Operating Procedure to WCET staff at wcet@uw.edu. The lab manager and relevant staff members will review the documents prior to approval. NO UNAPPROVED CHEMICALS ARE ALLOWED IN WCET LABS. We do not permit long-term storage of any personal chemicals in the facility without explicit permission. Inert and non-hazardous samples brought into the lab for analysis only do not require the submission of a Materials Request Form. However, all samples containing potentially hazardous chemicals must abide to the rules above, even if they are in the lab temporarily.

CHEMISTRY BENCH TYPES

There are 3 types of working spaces: lab benches, glove boxes, and fume hoods. Organic solvents are not allowed on plastic surfaces because they will dissolve the working surfaces. Acids and bases are not allowed on metal surfaces. You are responsible for understanding the specific requirements and chemical restrictions for each bench type. Glovebox training is required and available from WCET staff upon request.

AVOIDING FUMES

Fume hoods are designed to limit your exposure to chemical fumes. Check the status panel of the hood to make sure it is functioning properly. Many fumes in the lab are toxic, corrosive, or carcinogenic, so it

is important to only work under the sash for very brief periods of time and only when absolutely necessary. Most of the printing and coating tools cannot be placed in fume hoods, so fume snorkels are located near all fabrication tools. Be sure to open and properly position the nearest snorkel while printing and coating.

PERSONAL PROTECTIVE EQUIPMENT

You are required to use personal protective equipment (PPE) when working in the Scale-Up & Characterization Testbed. Rooms 110-113 require shoe covers, gloves, eye protection and a lab coat.

- Specifics:
  disposable non-woven lab coats provided by the lab are preferred, but personal, clean cotton lab coats are acceptable. No laundry service is provided. Dirty cotton lab coats are not allowed and users are responsible for proper cleaning of their cotton lab coats. **Do not clean lab coats in home washers and dryers.**
- Safety glasses must be worn at all times. Regular prescription glasses may be sufficient when not working with chemicals. Use face shields for high volumes (> 100 mL) of solvents.
- Nitrile gloves are provided, but proper chemical compatible gloves for your chemicals must be listed in your process SOP, and the user must provide the proper gloves for their process if nitrile is insufficient.

DONNING PPE

Check all items for damage before use. Look for cracks or pinholes in gloves, tears, holes, or missing fastenersin coats, and scratches or cracks in eye protection. If any gear is damaged, discard and replace it.

WEARING PPE

Do not touch anything unnecessarily with protective gloves and treat them as though they were contaminated. Do not leave the Scale-Up & Characterization Testbed while wearing protective gloves, unless directed to do so by staff and/or signs posted on the door in special circumstances. Wearing PPE is not an excuse to act in an unsafe manner. Do not ever put your hands or fingers into a chemical bath, and always avoid splashing or spilling chemicals. PPE provided by the WCET is only for temporary protection. It will not protect you from a spill, splash, or mist for a prolonged period of time.

DOFFING PPE

Gloves should be disposed of in lab waste containers. Safety glasses should be returned to the dressing location in the Room 112 vestibule. Shoe covers should be disposed of in the waste container outside of the entrance to Room 112. Lab coats should be returned to their hangers in the enclosed coat racks outside of the entrance to Room 112.

LABELING

Prior to filling or opening, all chemical containers must be properly labeled even if you do not intend to walk away. Use the pre-made sticky labels located to the left of the user information computer. You

must include your name (at least full last name and first initial), the full chemical name (no formulas or abbreviations), and the receipt, opening, and expiration (if applicable) dates. Note all hazards associated with the chemical by marking the appropriate checkboxes. If you plan to leave chemicals out after leaving the room, a phone number or email and an expected time of disposal must also be provided.

Non-hazardous substances such as water and common salts must also be labeled. If the chemical poses no hazard to users, write "Non-Hazardous" on the label.

POURING CHEMICALS

Immediately before pouring, always recheck the chemical label and make sure the chemical container you intend to use is set flat on the bench surface. Do not try to pour small volumes from gallon jugs; instead, transfer chemicals from gallon jugs to graduated cylinders or beakers, and then pour again from this secondary container. Use good judgment and do not overfill containers (i.e. do not fill them so close to the top that moving the container or disposing the chemical is unsafe).
Never return poured chemicals to their original container.

Use containers that are compatible with your chemicals. For example, some chemicals or solutions, such as piranha (a mixture of sulfuric acid and hydrogen peroxide), cannot be stored in closed containers even for brief periods of time because it outgases and could cause an explosion. Also, some acids cannot be used with glassware because they will dissolve the container.

CHEMICAL BOTTLE CLEAN-UP

Use chemicals in partially used stock bottles before opening new bottles. Properly clean empty chemical bottles before disposal. Leave empty solvent bottles open in a fume hood to evaporate. Alert staff that you have emptied a solvent bottle.

The contents of sample vials or tubes must be disposed of in the appropriate waste container, then the vials or tubes must be rinsed with the appropriate solvent to dislodge solid contents and dried. Once dry, the vials and tubes must be disposed of in the glass waste container.

DISPOSING SOLVENTS

To dispose of used solvent, empty it into an appropriate waste container. Clean the chemical container with an acetone soaked wipe, and then wipe thoroughly with isopropanol (IPA). Remove the label with acetone or IPA (do not bring a solvent squirt bottle into a plastic bench), rinse with DI water and return the container to the drying rack.

DISPOSING ACIDS AND BASES

To dispose of used acids and bases, empty them into an appropriate waste container. Rinse the container three times with water, then rinse with DI water. Take the chemical container to the south side of the room and remove the label with acetone or IPA on a wipe and then return it to the drying rack.

HANDLING SMALL SPILLS

Attempt only to clean small spills for which your training and experience are appropriate, provided you can do so safely without taking unnecessary risks. Large spills or spills outside of wet benches should be treated as emergencies. Refer to the Chemical Emergencies section of this manual.

Clean small solvent spills with lint-free wipes and dispose them in the laboratory waste can. Then use acetone and IPA with wipes to clean the surface(s). Clean small acid or base spills by thoroughly rinsing the surface with DI water. Do not wipe up chemicals directly with wipes without first rinsing and diluting the spill thoroughly. Once you are sure that there is only water left on the surface, dry the remaining drops of water with a wipe to leave a clean, dry surface.

Spill kits are available for cleaning general solvent spills. These kits contain: spill pads, baking soda, dust pan and broom, hazmat waste bags, splash goggles, impervious gloves, lightweight gloves, EH&S chemical collection request forms and hazardous waste labels.

HOTPLATE SAFETY

Do not touch hotplate surfaces. Use extreme care when hotplates are used in proximity to flammable solvents or other liquids. Do not spill on hotplates or spray water on hotplates, and do not heat high vapor pressure solvents. For example, do not heat up acetone or isopropanol. It is acceptable to remove hotplates from a wet bench if you need more room or if you feel more comfortable working without one in the hood. If you need to heat an organic solvent or material in a bottle, heat the container in a water bath, not directly on a hotplate.

LEAVING WORKSPACES

After using a bench or other workspace, clean up all chemicals, chemical containers, wipes, and other materials (samples, tape, markers, notes, personal effects, etc.). Always leave wet bench surfaces clean and dry within comfortable arms reach, and as organized as possible.

Emergency Procedures

You are strongly encouraged to read the Fire Safety & Evacuation Plan for WCET. This document has detailed information for most emergencies, as well as evacuation options for persons with disabilities. You are also encouraged to be familiar with the information found at websites like:

www.washington.edu/emergency/

www.washington.edu/safety

www.ready.gov

If you find yourself involved in a major emergency, do not be shy or embarrassed about calling for help or pulling the fire alarm. If possible, when emergency personnel arrive, approach them, tell them that you were involved in the incident, and be ready to explain what happened.

EMERGENCY COMMUNICATIONS

TELEPHONES

Use a cell phone or the campus telephone system to report emergencies. Use the user information phone inside the lab and dial 911 to report chemical emergencies only if it is safe to do so. In case of a system failure or a power failure, campus phones may not function. To dial campus numbers from campus phones, simply dial the last five digits of the number. To dial other local (206 area code) numbers, dial 9, followed by the ten-digit number.

Emergency Resource	Contact Information	Purpose and Responsibilities
UW Police Department (UWPD) Bryant Building 1117 NE Boat Street	Emergency Assistance: Dial 9-1-1. Non-Emergency Assistance: Dial 206-685-8973.	UWPD maintains an Emergency Communications Center 24 hours a day, 7 days a week. Call 9-1-1 for emergencies of any kind.
Environmental Health and Safety (EH&S) 201 Hall Health Center	Dial 206-543-0462. After normal business hours, EH&S may be reached through the UWPD using the EH&S Duty Officer system.	EH&S maintains guidelines and provides training, consultation and support for building emergencies. EH&S is also available to provide consultation and support for hazardous material spills and releases, temporary controls, and other general information to the Seattle Fire Department (SFD), UWPD, and UW departments.
Kidder Matthews Building Management (Abdul Samim)	Dial 206-255-6908 during business hours and 877-445-6782 all other times. Routine and emergency services (essential services are covered 24 hours a day).	Kidder Matthews operates the heating, ventilation, and air-conditioning systems (HVAC); and will handle the shutdown of steam, water, electrical, and other utilities.

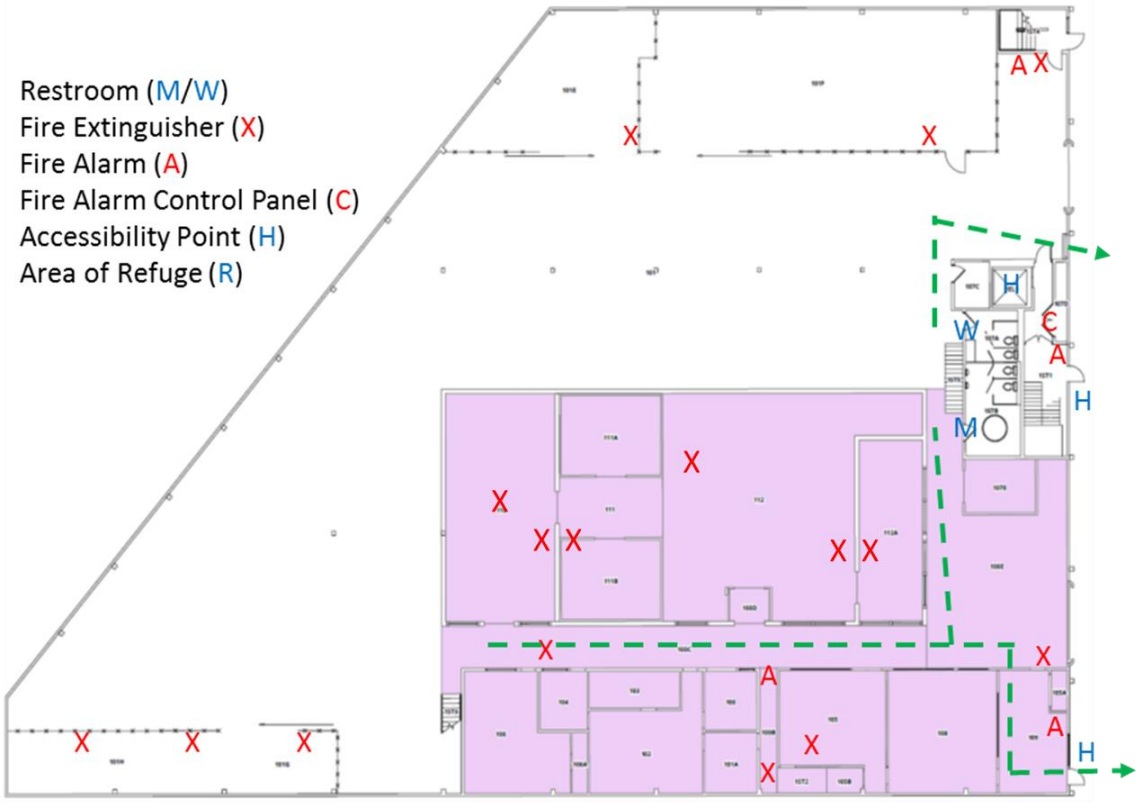
UW Emergency Operations Center (EOC)	The primary EOC is located in UW Tower, 4333 Brooklyn Ave NE, Room C-140. The secondary EOC location is Lander Hall, Room L-135.	For a major local or regional emergency, the UW President may request activation of the University's Emergency Operations Center (EOC). Information on missing persons, building emergencies, first aid, and other needs during a large-scale emergency must be provided to the EOC by using campus telephone systems, computer, (See Emergency Communications in Section 1) or by runner if the telephone systems fail.

FIRE ALARM SYSTEM

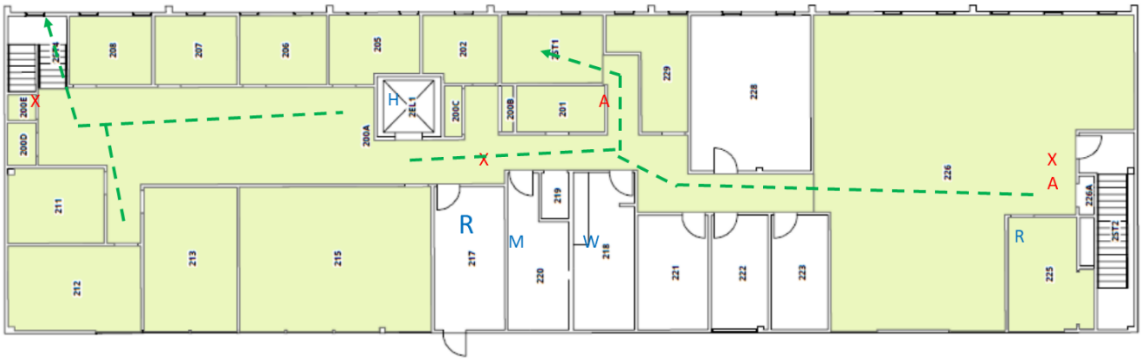
The building fire alarm system is continuously monitored by a contracted fire safety company. All alarms result in an automatic response by Seattle Fire Department, UWPD, and Kidder Matthews. Manual fire alarm pull stations are located on each floor and are shown on the Fluke Hall floor maps below.

EVACUATION PLAN

The floor plans below identify exits and exit routes for the building. Occupants should go to the nearest exit during and evacuation. If access to the nearest exit is obstructed, an alternate exit should be taken. Ground floor (top) and 2nd floor (bottom) are shown.



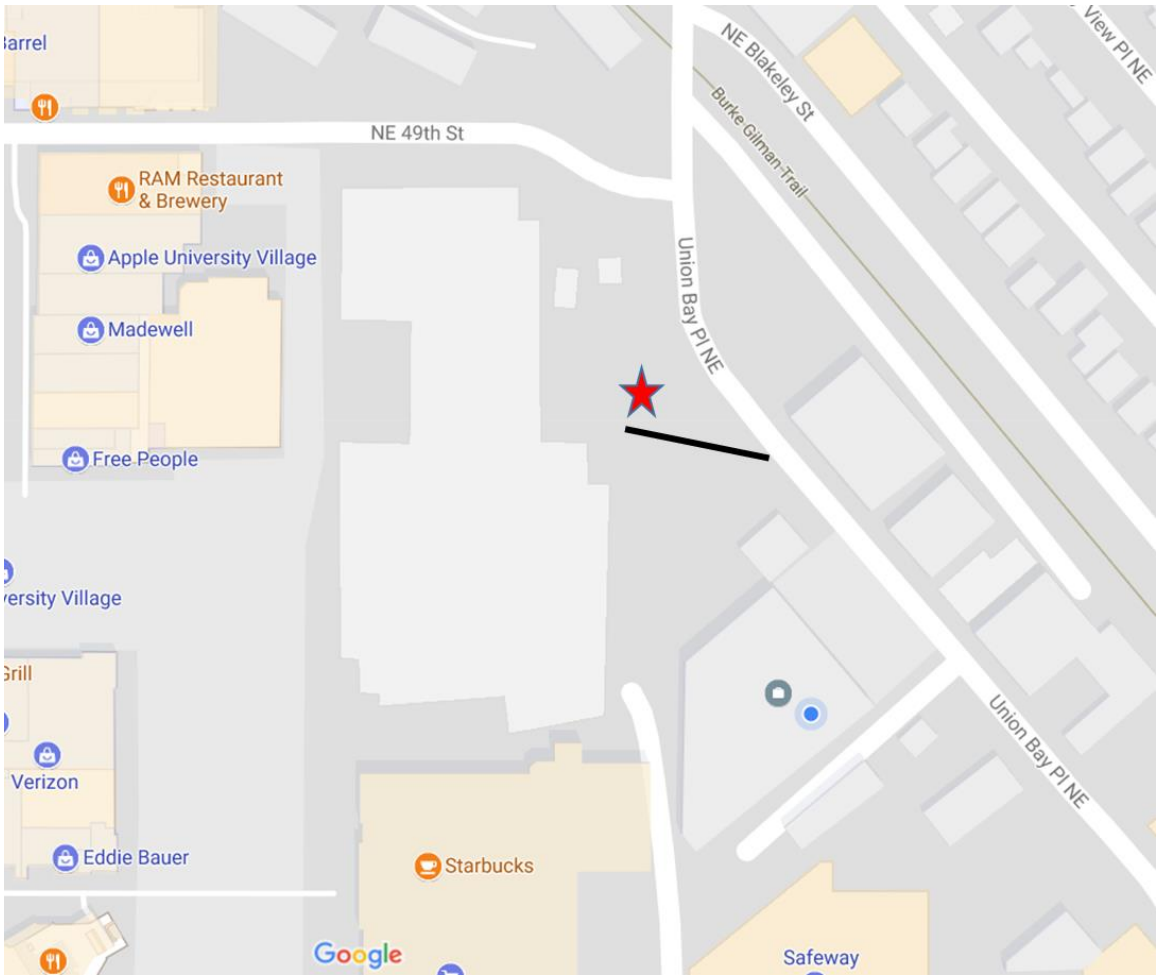
First Floor



Second Floor

EVACUATION ASSEMBLY POINTS

Assemble after an evacuation so the evacuation warden (yellow hat) can account for you and so you can lend assistance as needed. The primary evacuation assembly point (EAP) for WCET is the closed road north of the Goodwill drop-off location. The secondary evacuation point is the north entrance to the Safeway parking lot. If the Evacuation Director finds the primary EAP unsuitable, then evacuees will be moved to the secondary EAP. The Areas of Safe Refuge are located on either end of the 2nd floor and on the roof.



CHEMICAL EMERGENCIES

Spill Response – In order to become an onsite user, you are required to complete the UW EH&S Managing Laboratory Chemicals online training course. This training outlines chemical handling and emergency procedures. If you cause or encounter a chemical spill, respond accordingly based on the following scenarios.

- Risk of fire or spills that could spread out of the room: Pull the nearest fire alarm. This alerts the local fire and police departments that there is an emergency at your location and sounds the alarm in the building for everyone to evacuate. Leave the building, helping others as necessary. Then, if possible, call 9-1-1. Tell them what happened. Stay on the scene to help personnel respond to the emergency. Do not fight any fires yourself.

- No risk of fire, spill and vapor contained in the room, but someone is injured or exposed: Call 9-1-1 only. If someone has been exposed to a chemical, begin decontamination and/or first aid as soon as possible. Evacuate the room and wait for emergency personnel to arrive.
- Everyone is safe, but there is a large chemical spill: Contact the lab staff or call the EH&S Spill Advice Line during normal hours at 206-543-0467. After normal business hours, call 9-1-1 and ask for EH&S chemical spill advice. EH&S will advise you on how to clean up your spill or will call the UW's spill cleanup contractor to clean up the spill for you at the lab's expense. Notify lab staff as soon as possible.

Only attempt to clean small spills for which your training and experience are appropriate. If you feel comfortable and are properly trained, a spill cart is located in room 112 for any chemical spill that is not considered a HAZMAT emergency. Spill carts contain acid and base neutralizers, HF spill kits, mercury spill kits, caution tape for clearing an area, and personal protective equipment. Personal protective equipment includes nitrile and neoprene gloves, aprons, and face shields. Additional HAZMAT Level B suits are available on the spill cart for staff use only. Contact staff for large spills (>100 mL) or spills outside of a wet bench. Do not clean spills that occur outside of the fume hood that may require specialized respiratory protection (e.g. large acid or solvent spills, including any HF spills).

Regardless of the size of spill, contact the staff and report the spill details and if/how it was cleaned. Once the spill is handled properly and everyone is okay, the events need to be reported and discussed to improve spill prevention and evaluate the response as a laboratory group. Also, if you are involved in a spill, you must fill out an Online Accident Reporting System (OARS) accident report on the EH&S website. State and federal law requires that all accidents and near-misses be reported. The University of Washington also has committees that track accidents on campus in order to assess and improve campus safety.

Chemical exposures – Working with chemicals is dangerous. Even common mistakes like dropping a container or leaving a reaction unattended for "just a minute" can have serious consequences when chemicals are involved. Work carefully and deliberately; keep in mind what to do if things go wrong. Read the SDS for all chemicals you plan to use to ensure you are aware of hazards and emergency procedures. Avoid exposures by following the rules below:

- Don't work with chemicals when you're too tired to think clearly.
- Keep your workspaces clean and organized.
- Wear personal protective equipment

If you are exposed to a chemical (other than hydrofluoric acid, discussed in the next section), do the following:

- Stay calm. Move out of the contaminated area.
- Get the chemical off. Fast dilution is key. If the chemical is on skin or soaking through your clothing, go to the safety shower. Pull the handle on the safety shower, and do not worry about getting the floor wet. Stay in the shower for a minimum of 15 minutes, taking off all clothing necessary to minimize exposure to the chemical. Do not be modest, as your life may depend on removing soiled garments! Get coworkers to help shield you or cover you up. If the chemical is in your eyes, use the eyewash, holding your eyes open in the water for 15 minutes.
- Get a coworker to call 9-1-1 as soon as possible. Have them explain the situation to emergency

personnel.
- If possible, obtain an SDS to give to emergency personnel.

You must inform WCET staff if you have had an exposure to a dangerous chemical. If a hospital visit is needed, it is always valuable to take the SDS for the chemical to the hospital because the proper medical care can be better determined with the SDS.

Hydrofluoric acid exposure – Hydrofluoric acid (HF) is among the most dangerous chemicals in WCET, and the medical treatment for exposure is specialized and differs from that of most other chemicals. HF exposure is very serious, as it can cause severe burns, metabolic imbalances, pulmonary edema, and cardiac arrhythmias. As little as 100 mL is potentially lethal if untreated. HF and Buffered Oxide Etch (BOE) will not necessarily cause an immediate burning sensation, so respond quickly if you have had an exposure even if you do not feel any immediate pain.

- In the event of skin contact: remove clothing and flush the affected area for a maximum of 5 minutes. While rinsing, have someone call 9-1-1. Put on double nitrile gloves and then apply calcium gluconate gel, located on the HF wet benches, to the contaminated skin. This will help to neutralize fluorine ions.
- In the event of eye contact: use the eyewash for 15 minutes. Do not use calcium gluconate in your eyes! Call 9-1-1. Emergency personnel will treat eyes with a solution of calcium gluconate mixed with saline.
- In the event of inhalation: Call 9-1-1. Move to fresh air and wait for medical assistance.

If you are aiding someone experiencing HF exposure, wear black, neoprene gloves that offer the highest protection from HF, or double nitrile gloves if those are not available. The University of Washington.

EH&S provides details on HF hazards, exposures, spill cleanup, storage, etc. in a document that can be found at:
https://www.ehs.washington.edu/system/files/resources/Focus_Sheet-HF.pdf

FIRES

In the event of a fire, lab users should activate the nearest pull station and evacuate the building.

- When an alarm sounds, begin immediate evacuation following your floor plan. Close doors behind you.
- If you discover a fire, activate the nearest pull station, close the door and evacuate, and call 9-1-1.
- If the fire alarm does not work, call 9-1-1 and notify occupants verbally of the emergency and the need to evacuate. Evacuation Wardens or another responsible party needs to confirm that all occupants are notified.
- If you are on fire, STOP – DROP – ROLL. If another person is on fire, yell “STOP – DROP–ROLL.”
- Evacuate via the nearest stairwell or grade level exit. Do not block exit doors or wedge them in an open position. The doors must remain closed to keep smoke out and maintain safety for evacuation and fire personnel. Leaving doors open makes the stairwells dangerous and unusable. Persons with physical disabilities have several options (see Fire Safety and Evacuation Plan).
- Go to the Evacuation Assembly Point (EAP). Immediately report to an Evacuation Warden so

that he or she can accurately track which occupants were able to evacuate. Evacuation Wardens will report to the Evacuation Director.

- If you are trapped by smoke, stay low, cover your mouth with a wet cloth, stay near a window, open it but do not break it, hang something out the window to let fire personnel know you are there and put something in the cracks around the door, phone 9-1-1 if possible.

OTHER MEDICAL EMERGENCIES

There is a First Aid and CPR guide located in all first aid kits. These guides give detailed steps in the event of a heart attack, CPR, choking, bleeding, poisoning, and burns, as well as other injuries. EH&S recommends First Aid/CPR training for a handful of building volunteers to assist with medical emergencies associated with building evacuation and emergencies.

- Stay calm. Assess the situation. Look for a Medic Alert bracelet or necklace on the person requiring help.
- Have someone call 9-1-1. If you are alone, yell as loudly as possible for help. If you are unable to summon help, you have to call 9-1-1 first, and then return and assist the person to the best of your ability.

When calling 9-1-1, give the operator as much information as possible, i.e. type of emergency, what help is needed, exact address, building name, room number, telephone number, information from Medic bracelet or necklace, and victim information. Don't hang up until you are told to do so by the 9-1-1 operator.

- Do not move the victim.

For additional information visit https://www.ehs.washington.edu/system/files/resources/firstaidplan.pdf

Utilities Overview

Our primary utilities are standard and high voltage power, a compressed air, N2, and Ar gas delivery system, water, humidification control in the ECR. Many instruments require higher than normal voltage and current, DO NOT open power boxes or conduits. Do not adjust gas pressures in the utility room. WCET staff monitor gas supply daily. Alert WCET staff to all utility malfunctions.

Acknowledgements

This document was created using information from the Washington Technology Center User Manual, the Microfabrication Facility User Manual, and the Washington Nanofabrication Facility User Manual. The UW EH&S website and training documentation were also used extensively, sometimes word for word.