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Site-wide Operations in Support of the Mission of Los Alamos National Laboratory

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Los Alamos National Laboratory
Environmental Protection Division
Risk Reduction Office

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Los Alamos National Laboratory

Many activities are conducted at LANL to support its mission, including basic and applied research and development and facility maintenance and operations. These support activities, which occur in many locations at LANL, are described in detail below.

1.0 Facility Operations and Support Activities

Many activities are conducted at LANL to support research and development, including maintaining, preserving, and upgrading facilities and infrastructure, and maintaining general shop capabilities. These support activities range from routine maintenance and improvements for personnel safety and environmental health to support structure additions, changes, and upgrades and carpentry and electronic shop operations. These are described in detail below.

1.1 Routine Maintenance Activities

Maintenance activities are frequently and routinely performed for operational support of LANL facilities and property. These actions range from ongoing custodial services to corrective and preventive actions required to maintain and preserve buildings, structures, roads, infrastructures, and equipment in a condition suitable for fulfillment of their designated purpose. These activities are intended to maintain current operations and do not substantially extend the useful life of a facility or allow for substantial upgrades or improvements. Routine maintenance includes maintenance, repair, replacement, removal, relocation, fabrication, and installation actions. These activities take place at all LANL technical areas and occasionally at off-site leased facilities.

LANL performs routine maintenance on its facilities. Examples of these actions include, but are not limited to, the following:

- addition of weather protection structures (canopies, sheds, tension support structures) that protect equipment, fixtures, utility valves, switches
- correction of drainage problems around buildings
- lubrication and vibration analysis of rotating equipment
- minor/spot decontamination of equipment, rooms, and hot cells by wiping, using strippable latex, and vacuuming
- modifications to buildings to meet building, fire, and safety codes
- painting/plastering/staining/waterproofing of interior and exterior surfaces
- physical rearrangements of equipment
- provide temperature, humidity, and electrical equipment and controls to maintain ambient environment for proper operation of equipment

- testing/repair of back flow preventers
- testing/repair of emergency lighting
- maintenance/repair/replacement of
    - airport and fire department facilities
    - cafeteria equipment
    - compressed air systems (breathing air, liquid nitrogen, argon)
    - cranes
    - doors, windows, walls, ceilings, roofs, floors, stairways
    - electrical equipment (compressors, generators, transformers, pumps)
    - elevators
    - fencing, gates
    - filtration media in wastewater treatment processes
    - fire alarm equipment (heat detectors, smoke detectors, alarm panels)
    - fire control equipment (fire doors and fire dampers)
    - fire suppression equipment (sprinklers, standpipes, extinguishing systems)
    - lightning protection equipment
    - locks, cores, keys
    - mechanical testing equipment
    - monitoring equipment
    - office equipment
    - pressure vessels
    - product storage
    - safety equipment (alarm systems, eyewash stations, showers, self-contained breathing apparatus)
    - security systems (security alarm systems, camera equipment, towers)
    - spill containment systems
    - steam, condensate, chill water, chlorination, and reverse osmosis/deionization systems
    - structural platforms, catwalks, walkways, concrete pads

LANL performs routine maintenance on the roads, vehicles and grounds for which it is responsible. Examples of these actions include, but are not limited to, the following:

- installation and repair of parking signs, safety signs, direction markers, traffic signs
- installation and repair of culverts and other means of road drainage
- regrading of road shoulders and bar ditches
- surfacing /repair of roads and parking lots
- maintenance/repair of
    - guardrails, traffic barriers, traffic signals, curbs, gutters, sidewalks
    - highway vehicles, snow removal equipment, emergency response vehicles, drill rigs, trucks, construction vehicles, buses, tractors
    - pedestrian and vehicular bridges
    - unpaved access roads, fire roads
    - soil conservation efforts, such as,

  - application of fertilizers and other soil enhancements
  - ditch cleaning
  - erosion control
  - reseeding
  - revegetation
  - soil stabilization

LANL performs routine maintenance on the utilities in and around its facilities. Examples of these utilities include, but are not limited to, the following:

- communications systems
- cooling towers
- electrical wiring, gauges, valves, switches
- exhaust/drain systems
- gas lines
- heating, ventilation, and air conditioning (HVAC) systems and components (electrical, solar, natural gas, forced air)
- interior and exterior lighting systems
- plumbing
- steam and boiler plant equipment, natural gas heaters
- telephone or electrical distribution utility poles, cables, insulators
- unused equipment and facilities (disconnect utilities)

LANL performs routine inspections, support services, and custodial services for its facilities. Examples of these actions include, but are not limited to, the following:

- routine inspections/analyses
  - asbestos surveys
  - environmental monitoring, sampling, and analysis (on-site, local, and regional agricultural products, plants, animals, water, soil, and sediments)
  - equipment inspections
  - identification of PCB containing equipment
  - routine sampling for chemical and radiation hazards
  - safety inspections
  - tests, inspections of fire protection systems
  - water supply sampling and analysis
- support services for facility operation
  - architectural/engineering services
  - delivery of supplies and equipment
  - destructive/non-destructive testing of products for quality control or quality assurance purposes
  - equipment calibration

  - food services
  - laundry/dry cleaning
  - material shipping in accordance with DOT regulation
  - mobile equipment gas/fuel service
  - moving furniture
  - pick-up and recycling of paper, scrap metal, surplus equipment
  - printing/photographic services
  - removal of contaminated expendable supplies (labware, gloves, clothing) and treatment/disposal in permitted facilities
  - removal of outmoded, inadequate, underutilized, unused, or abandoned equipment, machinery, vehicles, and fixtures (ductwork, pipes, lighting, wiring) for salvage or disposal
  - safety, emergency response, and other worker training
  - testing and certification of technicians
  - transportation of excess chemicals for reuse on-site
  - waste transportation and permitted treatment/disposal for existing waste streams resulting from routine maintenance and custodial activities
  - custodial services
- cleaning of offices and other facilities
  - landscaping, lawn care
  - snow removal, road sanding (using sand or other materials)
  - trash collection
  - vegetation and pest control in accordance with regulations

1.2 Safety, Environmental, and Equipment Improvements

LANL routinely conducts safety, security, and environmental improvements to facilities, including installation of and improvements to equipment for personnel safety and health. Other environmental improvements include minor operational changes and equipment additions or modifications that reduce the volume of waste produced and facilitate reuse and recycling of materials. These activities are conducted at all technical areas, including leased spaces outside the LANL site boundaries and do not result in a significant change in the expected useful life, design capacity, or function of the modified facility.

LANL provides improved personnel access to safety equipment by installation of, improvements to, or replacement of:

- breathing air supply ports and lines
- eye wash stations and safety showers
- first aid kits
- protective clothing cabinets
- safety line rigging

- scaffolding
- self-contained breathing apparatus/respirator racks and cabinets
- spill kits

LANL reduces risks of personnel injury by installation, replacement, modification, and upgrade of:

- alarm systems and monitors
- anchors/bolts/braces/brackets/safety chains for equipment and furniture; pipe hangers and brackets
- bottled gas racks
- cable trays and covers
- cages for controlled access equipment
- cages for sprinklers, lightning, ladders, and similar equipment
- chemical supply cabinets
- compressed gas regulators
- continuous air monitors (CAMs)
- convex traffic mirrors (personnel, vehicles)
- door or equipment interlocks/disconnects
- electrical wiring, electrical components, and electrical safety devices (e.g., ground fault circuit interrupters, circuit breakers, conduits, surge protectors, outlet covers, outlet strips, fusible links, permanent wiring)
- emergency exits
- emergency shut-offs
- fencing of areas with safety hazards
- fire protection and control systems (detectors, sprinklers, standpipes, fire doors, fire extinguishers)
- flashback protectors
- floodlights and safety lighting
- gratings and plates over wall, ceiling, or floor openings
- guard rails, stair rails
- guards and other shields for equipment with moving parts (toe boards, guards for pulleys, pump shafts, fans, belts)
- handicap facilities (access ramps, toilets, sinks, handrails)
- inspection ports on equipment
- lightning protection systems
- non-skid flooring and steps
- physical barriers between waste handling/staging areas and worker/operations areas
- radiation shielding
- shock absorbers, bumpers, and stops on tracks, trolleys, roller drawers, cranes, hoists and similar equipment
- spark arrestors

- stairs, ladders, guardrails, handrails, walkways, and supports
- transformers, capacitors, generators and other small power supply systems
- wind socks
- wire glass windows, vision panels

LANL reduces safety risks at its facilities by:

- designating or installing satellite waste storage areas (areas for storage of less than 55 gallons of non-acutely hazardous waste and less than one quart of acutely hazardous waste)
- improving containment (such as tanks, drums, containers, enclosures) of radioactive or hazardous materials
- installing or improving inert atmosphere supplies to areas using flammable, pyrophoric, or explosive materials
- installing or improving remote handling equipment
- installing, improving, or replacing backup (redundant) power supplies and safety systems
- installing, modifying, and improving safe, secure storage areas for radioactive and fissile material in existing facilities currently used for activities involving the stored material
- providing access to equipment, pipes, monitors, and filters for repairs and inspections
- providing adequate fire protection capabilities (fire detection and alarm systems; fire suppression systems)
- providing better sanitary waste handling (sanitary holding tanks, septic tank systems, waste collection systems, lift stations, backflow preventers)
- providing fire breaks and fire roads
- providing structural bracing for reduction of seismic or other geological or meteorological hazards
- segregating incompatible process or waste materials (e.g., by installing firewalls or physically relocating materials)
- segregating previously common air exhaust, potable water, industrial water, wastewater, and fire control systems for different process areas
- separating radioactive materials management areas from offices and other areas where radioactive material control is not required
- upgrading components by replacing them with parts that have improved safety controls or are less susceptible to failure

LANL reduces potential personnel exposures by installing, modifying, and improving the exhaust systems for its existing operations. Quantities of emitted substances and rates of emission are not increased, nor are new types of pollutants be produced as a result of these upgrades. Exhaust systems include, but are not limited to, the following:

- air filtration systems
- ducts
- equipment for maintaining positive air pressure flow
- exhaust gas monitors
- fan controls
- fans
- fume hoods
- gloveboxes

LANL reduces risks to the public by reducing amounts of regulated substances in air emissions or water effluents by:

- reducing or eliminating contaminants in outfalls
- installing, modifying, replacing, removing, or improving
    - above and underground storage tanks, if there is no evidence of leakage
    - air and water filtration devices
    - effluent holding tanks, containment/release valves
    - ion-exchange devices
    - pH-adjustment and deionization systems
    - sand filters, flash tanks, pH neutralization tanks, aeration basins, and similar control systems in water/sewage treatment plants and steam plants
    - sanitary holding tanks, septic tank systems
    - scrubbers
    - settling tanks, equalization basins
    - spill control and containment structures
    - stacks and stack monitors
    - water disinfection tanks

LANL installs, modifies, and improves building and equipment instrumentation to protect human health and safety. This instrumentation includes, but is not limited to:

- announcement and emergency warning systems
- communications systems
- computer systems
- control systems to provide automatic shutdown
- criticality and radiation monitors and alarms
- fire and smoke detection and alarm systems
- float valves and shutoffs on tanks
- monitors and alarms for hazardous/radioactive substance concentration levels
- monitors and gauges on underground storage tanks and other product/waste storage containment structures

- non-destructive assay instruments (e.g., neutron counting instruments, gamma/X-ray counting instruments, calorimeters)
- oxygen concentration monitors
- pH probes/monitors
- pressure gauges
- pressure relief and control valves
- remote control panels
- remote monitoring systems
- safeguards and security equipment (badge readers, palm readers, outdoor lighting, camera mounts/towers, alarms and surveillance systems)
- scanning and alarm monitoring (SCAM) wiring and other liquid level gauges
- substation recording equipment

LANL installs, modifies, and improves its environmental systems, equipment, and controls including, but not limited to, the following systems:

- Heating, Ventilation, and Air Conditioning (HVAC) equipment and ductwork
- humidifiers/dehumidifiers/air dryers for humidity control
- air and water filtration devices (at intake and release points)
- surge protectors and power conditioning
- uninterruptible power supplies

LANL installs, modifies, replaces, or stores equipment and utilities to facilitate recycling of and decreased use of materials. Examples of these actions include, but are not limited to, the following:

- filtration systems to remove particulates and permit reuse of liquid or solid constituents
- distillation systems to separate and/or recover liquids of different degrees of volatility (for example, acids, solvents, etc.)
- piping systems to allow reuse of fluids (for example, cooling water, lubricants, machining oils, etc.)
- recovery systems to precipitate or collect materials (for example, silver in photo processing systems, lead, solvents, etc.)
- devices for decreasing the use of water (water-saving toilets, low-flow shower head, etc.)
- storage for chemicals to be reused or recycled
- storage for other materials to be reused or recycled, such as shielding blocks

LANL reduces waste production by installing equipment and implementing operational changes that

- identify waste streams and waste minimization options in project planning stages
- consolidate work activities to limit wastes generated from entry/exit or start/stop processes
- permit the use of smaller quantities of hazardous or radioactive materials to achieve the same results as do larger quantities of the same materials
- permit the use of microchemistry techniques to reduce chemical wastes
- substitute nonhazardous for hazardous materials to avoid production of hazardous or mixed waste
- substitute materials so that existing waste treatment can be more efficient and effective
- substitute reusable equipment and materials for disposable/one-time use items
- substitute radionuclides with short half-lives for those with long half-lives so that on-site decay
- eliminate radioactive waste
- modify processes so that resulting waste streams are more easily treated or contain more easily recycled constituents
- separate co-mingled waste streams
- reduce the volume of liquid materials used (including water)
- compact solid waste to reduce volumes
- establish tool, equipment, and material staging areas in controlled areas to prevent unnecessary contamination
- establish procedures to limit materials, including hazardous materials and chemicals, in radiological-controlled areas

LANL implements and modifies procedures for reuse and recycling of materials such as

- cardboard, paper, and packaging material
- aluminum, glass, and plastic
- other metals, such as steel
- wood products
- automotive/petroleum products
- chemicals, such as solvents, acids, and bases
- compost materials
- wipes, rags, and clothing

1.3 Support Activities

LANL sites, constructs, relocates, and operates small-scale support buildings and structures at all technical areas, including leased spaces outside the LANL site boundaries. Other activities include relocating structures, contents of structures, and processes; modifying support structures to provide space and furnishings necessary for support activities and to enhance workplace habitability; constructing short new access roads or modifying existing access roads to improve access; and decontaminating and decommissioning vacant structures.

LANL sites, constructs, relocates and operates small-scale support buildings and support structures within or contiguous to a developed area. Examples of these structures include, but are not limited to, the following:

- small permanent buildings
- transportables
- transportainers
- lockers
- tension domes
- temporary structures for field work

The structures are used for activities supporting the main scientific research and development mission of LANL. Support structures include, but are not limited to, the following:

- airport buildings, hangars, control towers, rooms
- cafeterias, kitchens, lunchrooms
- control rooms, guard stations, and security towers
- data processing facilities
- electronic equipment testing, fabrication, and repair shops
- fire stations and substations
- garages for equipment and vehicles (forklifts, dump trucks, passenger vehicles, vans, emergency response vehicles)
- health services facilities
- libraries, museums, exhibit areas
- mechanical property testing shops (provided no explosive or radioactive materials are used)
- offices
- passageways
- photographic processing darkrooms (provided hazardous waste recovery systems are connected to sanitary drainlines)
- radio dispatch facilities
- recreation facilities, exercise/fitness facilities
- security, safety, and environmental monitoring stations
- shipping and receiving facilities for commercial materials, laboratory supplies and standards

- shipping and receiving facilities for soil, rock, and other site characterization and monitoring samples
- shops for such activities as carpentry, welding, calibration, printing and machining
- solid waste compaction (excluding radioactive, hazardous, or explosive waste)
- storage space for materials, equipment, and supplies (computer components, radio and electronic equipment, compressed gases, custodial supplies, tools, janitorial supplies, packing and absorbent materials, water treatment chemicals, construction materials, administrative supplies, archaeological, biological, and geological specimens, publications and reference material, automotive parts, lubricants and additives)
- training/conference areas
- vehicle maintenance and servicing facilities
- visitor reception areas
- waste collection areas
- waste staging areas

LANL modifies its existing support structures and existing buildings to provide space and furnishings necessary for support activities. Examples of these remodeling modifications include, but are not limited to, the following:

- add new furniture, carpeting, pictures, bulletin boards, desks, whiteboards, bookcases, dividers, monitoring equipment, audio-visual equipment
- install walls, baseboards, thresholds, doors, windows, ceilings, cabinets, benches, sinks, restrooms, partitions, door hardware
- relocate furniture, workbenches, equipment, and utility connections
- remove walls, baseboards, thresholds, doors, windows, ceilings, cabinets, benches, sinks, restrooms, partitions, door hardware

LANL constructs, installs, operates, and modifies short term and long term safe, secure storage areas for its classified documents, radioactive material, and fissile material. LANL installs or constructs new safe, secure storage areas in existing facilities currently used for activities involving the stored materials. Examples of safe, secure storage areas include, but are not limited to, the following:

- vaults
- vault-type rooms
- cages
- floor holes

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LANL sites, constructs, modifies, and replaces-in-kind elements needed for the proper functioning of its existing support structures and buildings. Examples of these elements include, but are not limited to:

- above-ground storage tanks of 5000 gallons or less for petroleum products (diesel fuel, gasoline), lubricants, non-PCB dielectric fluids, detergents/surfactants, water conditioning chemicals
- access roads in previously cleared, developed areas
- catwalks, structural platforms, railings, ramps, walkways, ladders, stairs, loading docks
- fencing in developed areas
- freight and personnel elevators
- infrastructure in developed areas
    - communications and electrical cables and ducts
    - gas, water, and sanitary wastewater distribution and collection lines to existing mains
    - sanitary wastewater holding tanks
    - water tanks
    - other water supply and distribution system appurtenances
    - water booster, pump, and lift stations
    - water, sewer, and gas mains in existing utility corridors
- parking lots, sidewalks
- spill containment structures (curbing, berms, dikes, trenches, sumps and vaults, modular tanks) and associated pumps and piping
- temporary access roads to facilitate repairs to existing roads
- traffic signs and signals, turn lanes, bar ditches, culverts, dry arroyo crossings, guardrails, pullouts, and similar modifications to existing roads and highways
- weather protection structures (canopies, roofs, rain gutters) for outdoor equipment, loading docks, entryways

LANL relocates materials (such as clean fill, equipment, construction materials) and small buildings and structures (such as transportables, transportainers, trailers, lockers, tension domes, temporary structures for field work) and associated utilities from one site to another within LANL boundaries (excluding relocations between the main LANL facility and the LANL Fenton Hill site). Examples of the uses of these buildings and structures include, but are not limited to, the following:

- cafeterias, kitchens, lunchrooms
- communication facilities
- control rooms, guard stations, security towers, and security, safety, and environmental monitoring stations
- data processing facilities
- electronic equipment testing, fabrication, and repair shops

- equipment calibration facilities
- garages for vehicles (forklifts, dump trucks, passenger vehicles, vans, emergency response vehicles) and vehicle maintenance
- health services facilities
- laboratories
- libraries, museums, exhibit areas
- mechanical property testing shops
- mobile environmental monitoring or sample analysis facilities (trailers and vans)
- offices
- photographic processing darkrooms (providing hazardous waste recovery systems are connected to sanitary drainlines)
- recreation facilities, exercise/fitness facilities
- shops for such activities as carpentry, welding, and machining
- storage for nonhazardous, nonradioactive materials, equipment, and supplies (computer components, radio and electronic equipment, custodial supplies, tools, janitorial supplies, packing and absorbent materials, construction materials, administrative supplies, archaeological, biological, and geological specimens, publications and reference material, automotive parts and lubricants/additives)
- storage of products used for routine maintenance
- storage of chemical reagents
- training/conference areas
- vehicle maintenance and servicing facilities
- visitor reception facilities

The buildings, structures, and associated utilities are moved to developed areas where major utilities and roads are available. Only relocations for which there are no changes in overall operations or increases in emissions or waste streams are included. Relocations normally include the removal of construction debris, waste material, and unused utilities at the areas from which structures or facilities are removed. Restoration activities at the affected sites may include revegetation, reseeding, erosion control, or recontouring.

LANL relocates ancillary structures and facilities within developed areas at LANL for:

- waste staging and collection points, such as dumpsters
- material delivery drop-off points
- utility distribution and collection lines and connections to existing trunks or mains
- staging or storage clean fill or clean demolition debris in designated sites, such as the TA-16 or TA-61 borrow pits, or recycling and reuse of these materials in other project areas

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LANL relocates mobile units from and to both on-site and off-site locations. Activities performed by personnel with the mobile units include, but are not limited to, the following:

- site characterization
- environmental sampling and analysis
- environmental monitoring
- communications
- emergency response
- accident response

LANL modifies its existing buildings, structures, infrastructure, and equipment to enhance workplace habitability. These modifications include, but are not limited to, the installation, modification, replacement, and improvement of:

- awnings, canopies, decks, and similar structures
- clothes closets, racks, hooks
- computer workstations
- drinking water fountains
- electrical distribution and branch circuits
- ergonomic furniture and accessories
- handicap facilities (access ramps, toilets, sinks, handrails, Braille markings/labels)
- heating, ventilation, and air conditioning (HVAC) systems:
    - heating systems (including components such as boilers, hot water heaters, space heaters, gas or electrical heating furnaces, thermostats, ducts)
    - ventilation (including components such as window screens, exhaust fans, ducts, ceiling fans, forced air flow)
    - air conditioning (including components such as central air conditioning, ducts, window air conditioning units, evaporative coolers, covers for roof mounted/window mounted coolers and refrigeration units)
- humidifiers and dehumidifiers
- insulation, skirting, weather stripping, and other heat loss reduction materials
- kitchen areas and lunchrooms (including appliances such as refrigerators, microwave ovens, bottled water coolers, coffee makers, icemakers, dishwashers)
- lighting
- noise absorption materials (carpeting, ceiling materials)
- non-glare screens for windows and computer terminals
- radiation shielding
- recreation facilities, exercise/fitness facilities

- restrooms (including components such as toilets, showers, sinks, paper towel dispensers, soap dispensers, aerators and vacuum breakers on faucets, shower doors, mirrors, water saving devices)
- wind deflectors/barriers, rain gutters
- window blinds and shades
- windows

LANL constructs short new access roads and modify existing access roads within LANL technical areas to improve access to and within LANL technical areas and improve safety for workers. These modifications include, but are not limited to:

- constructing new onsite access roads
- changing road alignment
- widening roads
- adding turn lanes
- adding acceleration/deceleration lanes
- upgrading entries and exits
- grading
- shoring up
- installing erosion control measures
- adding guardrails to existing roadways

Major modifications to the principal LANL road corridors (Pajarito Road, East West Jemez Road, etc) and those that would change overall access to LANL by workers and the public are not included. Consolidation or expansion of operations and facilities within existing TAs are also not included.

Prior to construction activities, archaeological and biological surveys are conducted to ensure that proposed projects do not impact these resources. Best management practices are used throughout construction projects to prevent erosion from work sites. All disturbed soil is stabilized and revegetated. Storm Water Pollution Prevention Plans (SWPPPs) are followed, as well as other water quality requirements. Activities conducted in or near Solid Waste Management Units (SWMUs) are conducted according to federal and state regulations.

1.3.1 General Shop Operations

A variety of shops support many facility maintenance and research activities at LANL. These shops include machine shops, carpentry shops, and electronics shops. These shops produce and customize specialized tools, equipment, and parts for scientific research. The shops also construct items needed for facility modifications, such as customized railings, scaffolds, and weather protection shelters. Many different types of equipment are used, including drill presses, lathes, bench grinders, table saws, sanders, welding equipment, small power tools, hand tools, and other common shop equipment. Materials most commonly used include nonhazardous metals, ceramics, wood, plastics, rubber, epoxies and glues, paint, solder, sealant, small quantities of cleaning solvents, and other common shop materials. Specialized shops may also use a variety of hazardous or radioactive materials in fabrication and construction.

1.3.2 Physical Support and Infrastructure Facilities

The TA-60 (Sigma Mesa) facility contains a number of physical support and infrastructure facilities, including roads and grounds activities (such as asphalt batch plant, road salt dome, and motor pool facilities), waste management activities (such as material recycling facility and evaporation ponds), and storage and other facilities (such as erosion control material and utility equipment storage areas). This area contains occupied New Mexico Spotted Owl habitat and several archaeological sites.

1.3.2.1 Roads and Grounds Facilities

Roads and grounds facilities located at TA-60 include: asphalt batch plant (maximum of 80 tons of asphalt per hour) plus attaching utilities and erosion protection area; rock crushing equipment and storage areas; salt dome for storage of road salt for use during winter months; motor pool facilities, including fueling stations (such as gasoline, diesel, and alternative fuels) and maintenance areas; heavy road equipment storage and maintenance areas; soil, rock, and other road material storage areas; and Roads and Grounds Facility office space.

1.3.2.2 Waste Management Activities

TA-60 waste management activities include: demolition waste storage and processing areas; material recycling facility (asphalt, stone, soil, glass, metal, paper, etc.) plus staging area for material recycling; evaporation ponds for outfall reduction; and petroleum-contaminated soil storage area and bioremediation treatment area.

1.3.2.3 Storage and Other Facilities

Additional storage areas and other facilities at TA-60 include: Water Quality and Hydrology equipment and material storage; erosion control material storage (wattles, seed, etc.); utility material storage area (such as electrical equipment, conduit, etc.); general surplus equipment and material storage; communications office building; radio shop; and road access into Sandia Canyon.

1.4 Decontamination and Decommissioning of Vacated Structures

LANL decontaminates and decommissions (D&D) vacant structures (including buildings and other structures such as septic tanks and manholes) determined to be excess to current and foreseeable needs. Decontamination may be a part of demolition activities. For each structure proposed for demolition, expected waste volumes, date of construction, and the National Register of Historic Places status are identified prior to demolition. Septic tanks are not expected to contain radioactive waste but are sampled and characterized during the D&D process.

A D&D plan is developed for each structure and includes:

1. Site sampling for solvent residues, hazardous materials, and highly flammable materials including high explosives residues and radioactive materials.
2. Removal of rodents and rodent excrement.
3. Asbestos abatement as described in LAN-97-106, Asbestos Abatement/Removal
4. Decontamination of RCRA-regulated hazardous components, PCB-containing items, lead, high explosives (HE), and radioactive contamination. Decontamination is conducted by LANL personnel or subcontractors
5. Demolition. Frame structures are disassembled by hand. Concrete structures and pads are demolished mechanically. Piping is excavated by hand and with machinery. Uncontaminated wood, piping, tanks and equipment are released to salvage for reuse. Wood painted with lead-based paint is steam cleaned and disposed of in the Los Alamos County Landfill if the lead content is below the TCLP limit. If above the limit, it is managed as hazardous waste. Concrete slabs and block are broken up with heavy machinery, crushed and reused as fill material or in road building if possible.
6. Removal of utility connections.
7. Excavation and removal of piping, septic tanks, and sumps.
8. Site restoration including backfilling trenches and pits and revegetation.
9. Waste management including trash and rubble, wastewater, RCRA, HE, radioactive, mixed and low-level waste. Contaminated waste is managed on-site, or shipped off-site for disposal, treatment or treatability studies. Uncontaminated waste is disposed of in the Los Alamos County Landfill. If water is used for decontamination of HE, then the water is collected and treated at the HE Wastewater Treatment Facility. Wastewater generated by asbestos abatement activities is filtered to remove asbestos, then treated at the LANL sanitary waste treatment plant. Radioactively contaminated wastewater is collected and treated at the Radioactive Liquid Waste Treatment Facility at TA-50.

Some of the structures are potentially eligible for the National Register of Historic Places. Cultural resource evaluations are conducted for each structure by LANL cultural resource staff members; consultation with the New Mexico State Historic

Preservation Officer (SHPO) occurs when warranted. A data recovery plan is prepared, approved and executed if appropriate.

Some structures may be located in Environmental Restoration Program Potential Release Site locations. Soil disturbance at these D&D sites is minimal so as to preclude a release of contamination to the environment.

LANL staff biologists conduct biological evaluations for the presence of threatened and endangered species or other sensitive species. D&D actions may be subject to seasonal restrictions or other standard measures to protect species. LANL biologists and the New Mexico Fish and Game or US Fish and Wildlife Service consult when appropriate. They also review D&D plans to determine whether D&D could adversely affect floodplains or wetlands. If needed, D&D plans are modified to prevent adverse impacts or determine if mitigation is necessary.

Storm water pollution prevention plans and spill prevention, controls and countermeasures implementation plans are reviewed and approved by LANL subject matter experts for implementation during the project.

Each action is reviewed following the standard LANL excavation permit system. Dust created during operations is mitigated by standard dust control measures. If buried materials, utilities, archaeological sites, etc. are encountered, work is halted until the materials have been evaluated and the appropriate actions were taken.

LANL Air Quality staff review D&D plans to determine if any activities require a permit for radioactive air emissions under 40 CFR 61, a formal notification to the New Mexico Environment Department for asbestos abatement and demolition activities, or a permit for open burning of dangerous materials (such as HE contaminated waste).

Workers follow accepted noise control techniques and procedures to protect hearing. They receive appropriate hazardous materials, radioactive materials, respirator, high-energy source and HE materials training and wear appropriate personal protective equipment. Hazard control plans, standard operating procedures, special work permits and monitoring devices are used as needed.

1.5 Security and Protective Force Operations

1.5.1 Live Firing Range

LANL operates a live firing range at TA-72, which is used by Protection Technology Los Alamos (PTLA) personnel to satisfy DOE and LANL training requirements. The live firing range is used for training with machine guns, hand guns, rifles, grenade launchers, and other small arms. Qualification courses for these weapons are designed to verify the shooter's skills in manipulation and marksmanship under daylight and nighttime conditions. A variety of targets are used for training purposes.

A live fire shoot house is also located at TA-72, and consists of ballistic resistant, modular steel panels that can be moved to allow for different sizes and shapes of the shooting area. Certain shooting exercises require a long and narrow shooting area while other exercises can be performed in smaller areas. The shoot house is used for covert and dynamic tactical entry training for PTLA personnel. Bullet traps are placed behind each target to prevent impact of the bullets onto the modular panel walls, thereby preserving the integrity of the structure.

The surface danger zone (the total of the impact area and ricochet area extending the maximum range needed for the weapon in use) is within the fenced area, which is posted with permanent signs warning persons of the danger of the live firing range and prohibiting trespassing. Secondary danger areas are located outside the surface danger zone, and extend 100 meters on all sides. The small arms live fire range extends for 100 meters, and the grenade launcher range extends for 400 meters.

The live firing range and all associated structures meet DOE's Range Design Criteria. A variety of ammunition is used for training, including practice rounds, live rounds, tracer ammunition, and paintball rounds. Spent ammunition impacts a berm at the back of the firing range. PTLA personnel follow all safety requirements outlined in a Live Fire Range Safety Assessment.

There are several cultural resource sites located in the training area. Several cliff dwellings are present on canyon walls and an artifact scatter is located on the canyon floor. All sites are avoided and are not impacted by these operations. Much of the training area is located within core or buffer habitat for the Mexican Spotted Owl. LANL biologists ensure that training activities do not impact this natural resource. A Storm Water Pollution Prevention Plan (SWPPP) is in place for TA-72 and water resources are not impacted by these activities.

1.5.2 Hazardous Devices Team Training Facility

The Hazardous Devices Team (HDT) conducts training activities at its TA-49 firing site facility. HDT personnel offer periodic bomb threat preparation and response courses. These courses are designed to made LANL employees and other federal and state agencies aware of the destructive power of criminal or terrorist explosive devices and to give them the tools needed to identify suspect devices and to properly respond to those threats. As part of this training, detonation demonstrations are conducted using a variety of standard explosive materials (such as C-4 high explosive) and devices (such as a disrupter device, which uses a high-pressure jet of liquid to rapidly disassemble electronics within a simulated suspect explosive device).

1.5.3 Detector and Monitoring Training

LANL provides training to personnel from LANL, other DOE facilities, and other federal and state agencies in the use of radiation detectors and monitors. Training may include detection of radiological devices, radioactive materials, and hazardous materials. The monitors and detectors used during training uses of sources containing small quantities of radionuclides in order to check or calibrate the instruments. Some detectors use isotopic sources for active interrogation including, but not limited to, californium, plutonium-beryllium, or americium-lithium.

Training may be focused on vehicles, equipment, buildings, or other structures. The purpose of the training is teach and demonstrate the procedures for determining the contents of training standards containing radiation sources, hazardous material surrogates, or radioactive materials, including small quantities of special nuclear material. Radiation sources are either sealed or unsealed. Unsealed sources and special nuclear material are clad or encapsulated and all applicable control procedures are followed. Occasionally, short-lived radioactive materials may be used in indoor or outdoor exercises to provide realistic training scenarios. Training is conducted in buildings and outdoor areas that meet safety and authorization basis criteria for the proposed training. Training exercises are subject to environmental regulations and best practices and to the directions of a radiological control technician and are performed in accordance with applicable DOE Orders and LANL requirements, including adherence to the ‘as low as reasonably achievable’ (ALARA) principle. Handling and storage of sources and materials are performed in accordance with existing standard operating procedures (SOPs). Monitors and detectors used during training conducted at other LANL and off-site locations are operated by qualified personnel with appropriate training and all applicable work requirements are followed. The packaging and transportation of radioactive material used during off-site training exercises is conducted according to all applicable LANL procedures and U.S. DOT regulations.

1.5.4 Wildfire Response Activities

The Interagency Helibase Operation is located at the junction of the entrance road to TA-49 and State Road 4 and is used for wildfire response and storage for interagency wildfire response equipment and supplies. Personnel from LANL, Los Alamos County, the National Park Service, and the U.S. Forest Service staff the facility. The facility consists of three helicopter pads (helipads), two at-grade dip tanks (one 1500 gallon and one 3500 gallon tanks), a building, office trailer, and other associated infrastructure. During the fire season, Helitac personnel (helicopter crews plus additional maintenance staff) also staff the facility. The building houses two fire engines, fire equipment, and office space for emergency management.

Except during emergency situations or for safety reasons, the flight path to and from the helibase is from the south or east to the extent possible to avoid sensitive habitat located in the northern and western canyon areas. In addition, administrative controls prevent recreational use of the canyons surrounding the site. All cultural resource site boundaries within the helibase area have been marked and are avoided.

2.0 Environmental Restoration and Environmental Research

2.1 Environmental Characterization and Limited Removals

LANL conducts site characterization activities to identify potential release sites (PRSs) - landfills, pits, Material Disposal Areas (MDAs), and Solid Waste Management Units (SWMUs); canyon side disposal areas; major canyon systems; septic and disposal tanks; waste and drain lines, leach fields, and outfalls; storage drums, tanks, and facilities; firing ranges and impact areas; existing or former buildings and bunkers; and subsurface contamination areas. LANL also conducts final disposition of those areas proposed for no further investigation.

ER Project personnel work closely with LANL biologists and archaeologists, to ensure that biological, archaeological, and cultural resources are not impacted by the proposed investigations. Operations are scheduled and conducted so as to avoid harming cultural resources, as well as threatened or endangered species or protected habitat. LANL archaeologists and biologists consult with the New Mexico State Historic Preservation Office (SHPO) and the U.S. Fish and Wildlife Service (USFWS), as necessary, before ER Project personnel begin work. Before beginning activities, field teams are briefed about the culturally sensitive areas present in each work location. ER personnel follow biological mitigation measures and best management practices (such as minimizing off-road travel).

All activities are conducted according to existing and current safety plans and standard operating procedures to maintain worker exposure as low as reasonably achievable. Public safety is a primary consideration at sites near and around residential and commercial areas. Reviews of potential disturbances of archaeological/cultural resources and any consultations with affected Native American Tribes are conducted prior to initiating the proposed actions. If required, new or revised Biological Assessments (BAs) for proposed actions are submitted to the US Fish and Wildlife Service (USFWS) identifying sites with potential Threatened and Endangered Species (TES) and critical habitat issues. Proposed actions do not take place until the USFWS concurs with the proposed actions and mitigations identified in the new or revised BAs.

2.1.1 Characterization

Field investigations are designed to determine the type and location of contaminants. Radiological screening and screening for volatile organic vapors may be performed during the field sampling activities. Temporary onsite immunoassay laboratory and equipment are used to aid in the screening process. All soils removed during sampling are staged in a pre-determined staging area. Field investigation tasks are summarized in Table 1. Other contamination could include: PCB transformers; operational releases; spills; contamination under existing and former buildings; and other miscellaneous SWMUs.

Some limited, small-scale studies may be implemented in these canyons, including outdoor monitoring activities such as surface water flow monitoring or sedimentation characterization. LANL may also engage in expedited cleanups, such as limited removals to facilitate site characterization, interim measures (as defined in RCRA), or full-scale cleanup or closure of sites recognized as having a perceived public risk associated with them.

Table 1. Field Task by SWMU Types

Investigations	**SWMU TYPES**							
Tasks	Surface Disposal	Land-fills, Pits, & MDAs	Septic & Disposal Tanks	Waste & Drainlines, Leachfields, & Outfalls	Waste Treatment	Storage Drums, Tanks, & Facilities	Firing Ranges & Impact Areas	Other Contamination
Field Surveys								
Geophysical	X	X	X	X	X	X	X	X
Radiological	X	X	X	X	X	X	X	X
Soil Gas		X		X	X	X		X
Surface Sampling								
Soil	X	X	X	X	X	X	X	X
Channel Sediments	X	X	X	X	X	X	X	X
Air	X	X						
Water	X	X	X	X				
Flora/Fauna	X	X	X	X	X	X	X	X
Surface Sampling								
Boreholes 12"-10'	X	X	X	X	X	X	X	X
10'-50'	X	X	X	X	X	X	X	X
50'-200'		X	X	X				X
over 200'		X	X					X
Trenching/Test pits	X	X		X				X

Personnel collect sediment and core samples, as well as surface water, alluvial water (from background and observation wells), and water from the intermediate perched zones. Air samples (total suspended particulates and PM10) are also collected, as well as biological samples, consisting of garden produce, garden soil, wild plant species, and livestock forage plants. Samples are analyzed for a suite of chemicals of potential concern (CPOCs), which include radionuclides, organics (such as PCBs, pesticides, and semi-volatile organics), and inorganics (such as arsenic, chromium, and lead).

The initial sediment sampling strategy uses radiological surveys and geomorphological mapping to give a broad view of the distribution of contaminants. Discrete sampling points are then identified. Surface and groundwater investigations focus on areas most likely to contain contaminants. Ephemeral surface water within canyons is collected and analyzed during times of surface flow. Groundwater is sampled by drilling boreholes that intersect the groundwater bodies. Studies of the deep unsaturated zone and the main aquifer are conducted if determined necessary. Results of the groundwater investigations are used for locating and designing groundwater monitoring systems. A variety of equipment is used to conduct these studies, including, but not limited to, pressure transducers, sampling pumps, stream gauging and sampling stations, drill rigs, hand tools, trenching equipment, Geiger counters, laser-induced breakdown spectrometer, X-ray fluorescence spectrometer, ground penetrating radar, and others. Possible contaminants that may be encountered during the site characterization activities include: radionuclides, chemicals including volatile organic compounds, semivolatile organic compounds, and inorganic compounds, heavy metals, high explosives, waste oils and fuels, PCBs, sanitary waste, and construction debris.

2.1.2 Limited Removal Activities

In addition to the site characterization activities, some limited removal activities, voluntary corrective actions, are performed during this time to facilitate site characterization and to eliminate possible source term or human health risk or perceived risk. These removals may include non-active septic tanks and associated piping, near-surface piping, drainlines and other near surface debris with probable internal contamination, and small localized spots of contaminated soils. All materials removed are evaluated to ensure proper handling in accordance with health and safety requirements.

Geology, Geochemistry, and Hydrology Research

Basic and applied geology, geochemistry, and hydrology research studies are conducted on rock, concrete, soil, and other geological samples. Research is focused on various areas, including transport of contaminants in saturated and unsaturated hydrologic systems, carbon sequestration, basin-scale hydrology, zero-emission coal technology, volcanic geology and hazards, and planetary astrobiology and geology.

Research laboratory and outdoor activities are conducted. Thousands of geological samples are analyzed annually. In addition, instrumentation for conducting these studies is designed, tested, or modified. Outdoor hydrological and geochemistry experiments are conducted at TA-51 and other locations.

Research laboratory activities. Researchers study Earth materials and Earth systems. A number of different laboratories are used, including a wet chemistry laboratory, an X-ray diffraction laboratory, thermal analysis capabilities, optical equipment, a light-stable isotope laboratory, electron microanalysis, an X-ray fluorescence laboratory, and a mass spectrometry laboratory. Equipment used includes, but is not limited to, electron microprobe, infrared spectrometers, optical microscopes, scanning electron microscope, scanning probe microscope, inductively coupled plasma emission spectrometer, gas chromatographs, mass spectrometers, ion-liquid chromatograph, atomic absorption spectrometer, high-pressure liquid chromatograph, gas chromatograph, X-ray diffractometers, X-ray fluorescent spectrometer, autoclave, and other similar equipment.

Outdoor activities. As part of this work, researchers conduct outdoor field experiments at study plots located at TA-51 and other locations around LANL. Hydrological studies (such as erosion and water balance), carbon sequestration and carbon inventory studies, and other geochemistry and geology research are conducted. Laser-induced breakdown spectroscopy (LIBS), light detection and ranging (LIDAR), and other high-energy sources are used, as well as soil sampling equipment, runoff collection systems, and other equipment and materials.

2.2 Environmental Research

Environmental research at LANL encompasses a number of different capabilities, including geology, geochemistry, and hydrology research; atmospheric, climate, and environmental dynamics; geotechnical engineering; environmental geology and spatial analysis; geophysics; and planetary physics.

2.2.1 Geology, Geochemistry, and Hydrology Research

Basic and applied geology, geochemistry, and hydrology research studies are conducted on rock, concrete, soil, and other geological samples. Research is focused on various areas, including transport of contaminants in saturated and unsaturated hydrologic systems, carbon sequestration, basin-scale hydrology, zero-emission coal technology, volcanic geology and hazards, and planetary astrobiology and geology. Research laboratory and outdoor activities are conducted. Thousands of geological samples are analyzed annually. In addition, instrumentation for conducting these studies is designed, tested, or modified. Outdoor hydrological and geochemistry experiments are conducted at TA-51 and other locations.

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2.2.2 Atmospheric, Climate and Environmental Dynamics

Researchers conduct modeling, simulation, field measurements, and data analysis in the atmospheric, ocean, and ecohydrologic sciences. Current projects include 1) atmospheric, climate, and ocean modeling--wildfire behavior modeling, biogeochemistry and ocean carbon cycle modeling, climate applications to high performance computing, etc.; 2) ecology--semiarid systems ecology, soil science, carbon sequestration, micrometeorological instrumentation and analysis, etc.; 3) hydrology--surface and subsurface modeling, water resource prediction, contaminant fate and transport, erosion, etc.; and 4) weapons phenomenology and infrasound--physics and chemistry of atmospheric composition, theory and modeling of electromagnetic radiation, data analysis from satellites and ground sensors, etc.

2.2.3 Geotechnical Engineering and Research

Geotechnical research involves underground and surface geologic, seismic, volcanic, hydrologic, hydrogeologic, geophysical, and geochemical field testing, monitoring experiments, and managing samples. Past and present research has focused on the Yucca Mountain Project, and has involved evaluating engineering barrier systems, coordinating field testing, and studying the potential effects of a volcanic eruption. Other geotechnical studies could be conducted at LANL or other locations.

2.2.4 Environmental Geology and Spatial Analysis

Environmental geology and spatial analysis research focuses on the study of uncertainties associated with complex natural environmental systems and finding solutions to problems that arise as the result of human activities. Research capabilities include: volcanic and seismic hazards, geomorphology and surface processes, geochemistry, geographic information systems, environmental modeling and risk assessment, and quality assurance and data validation. Researchers are responsible for the quality assurance program at Yucca Mountain. They conduct environmental restoration work at LANL to evaluate present-day human health and ecological risks from contaminants that entered canyon areas. They also evaluate seismic hazards to LANL's nuclear facilities and conduct paleoseismic and structural geology studies.

2.2.5 Geophysics

Basic and applied geophysics research at LANL focuses on exploring the seismic and acoustic signals that provide information about disturbances, both natural and manmade, within the earth's crust. Research is conducted in the following areas: 1) nuclear explosion monitoring—processing and interpreting geophysical and geological data for the national ground-based nuclear explosion monitoring program; 2) geodynamics—developing and applying computational tools and experimental methods for predicting the response of geological materials to large and rapid deformations; 3) seismic modeling and imaging—conducting basic and applied research in wave propagation, seismic imaging, scattering, and the interaction of acoustic waves with rock mass structure, fabric, and pore fluids; 4) drilling—developing advanced drilling methods and tools for drilling operations for the LANL Environmental Restoration Project and for oil exploration for National Energy Security; and 5) national defense—offering geology/geophysics expertise in the geologic phenomena associated with explosion dynamics both subsurface and above ground, and intelligence gathering and interpretation using remote sensing techniques.

2.2.6 Planetary Physics

The Institute of Geophysics and Planetary Physics (IGPP) promotes and coordinates basic research on the understanding of the origin, structure, and evolution of the Earth, the Solar System, and the Universe, and develops the science base to predict future changes as they affect human life. Research is conducted in the following areas: 1) astrophysics—theoretical, observational, and instrumentation research on gamma-ray astrophysics, space instrumentation, stellar dynamics, etc.; 2) space physics—theoretical, computational, and observational research into the plasma environment of the earth; 3) solid planetary geoscience—numerical, seismic, paleomagnetic, and laboratory studies of the geophysical and geochemical structure, properties, processes, and fluid dynamics of terrestrial and giant planets.

2.2.7 Facilities and Equipment

A number of different facilities and equipment, in addition to those already outlined above, are used to conduct this research. Laboratory equipment used includes geochemical instruments for rock, mineral and water analyses; geophysical laboratories for electrical and acoustical properties measurements; a drilling research laboratory; electrical/mechanical shops for the fabrication of borehole instruments; a geographic information system; and a greenhouse, wet chemistry lab, and related facilities for ecological studies. The field equipment includes portable seismometers and other exploration geophysical equipment, a permanent seismic network in the Los Alamos areas, drilling rigs (including mechanical shops), ground penetrating radar, and LIDAR and meteorological measurement equipment.

2.2.8 Archaeological Site Evaluation

LANL evaluates archaeological sites located at LANL technical areas and surrounding locations (such as U.S. Forest Service land). Sites are evaluated to establish site integrity that is subsequently used to determine the National Register of Historic Places eligibility of the site.

Depending on the site type, ground penetrating radar (using a 500 MHz antenna) and other geophysical instrumentation is used to identify the location of potential subsurface archaeological deposits. Auger holes (one meter deep or greater) or shovel tests (50 centimeter square holes) are then excavated to determine if intact subsurface cultural deposits exist at specific grid locations across the site. In addition, test pits (100 centimeter square holes, up to 1.5 meters deep) are dug to verify the existence of intact cultural deposits that have been suggested by the ground penetrating radar and/or the auger/shovel test holes. Cultural resource specialists then analyze the available data.

These archaeological evaluation activities do not impact any biological resources and are for the purpose of determining whether cultural resources deposits are present and have integrity.

2.2.9 Biological Field Studies

LANL biologists conduct field studies to inventory, monitor, and assess vegetation and animal populations. Small-scale netting or live trapping is conducted to collect specimens for examination. Data collection includes recording reproductive patterns, species distribution and densities, and habitat use. Specimens may be marked before release for later identification. Some trapping methods result in negligible mortality rates for small mammals, reptiles, and insects. Some samples may be collected from road-kills to evaluate diet or contamination.

Vegetation, fruit, and produce samples may be collected from LANL or offsite locations for analysis of biomass, fuel-loading, contamination, or other attributes. Sample areas may be fenced for the duration of a study to prevent disturbance between scheduled fieldwork. LANL may also conduct phytoremediation and bioremediation studies both in natural and constructed settings.

2.2.10 Water and Soil Monitoring

Water monitoring stations are installed, maintained, and operated to measure flows, evaluate water quality, and test for contamination. Locations for monitoring stations are based on the characteristics to be studied. The locations are reviewed by cultural and biological resources specialists to ensure protection of sensitive resources. Soils and sediments are sampled on a regular basis from a variety on locations at LANL and offsite.

Groundwater monitoring wells are also established to monitor groundwater characteristics and to determine the presence of contamination. Locations are reviewed by cultural and biological resources specialists to ensure protection of sensitive resources. Monitoring wells are designed to prevent surface contamination from reaching subsurface water.

3.0 Applied and Material Science

LANL conducts a variety of basic and applied materials science research, which is conducted on a wide variety of materials, including ultra-high strength and high energy density materials, radioactive materials, high explosives, heavy metals, gases, geological samples, ceramics, amino acids, superconductors, intermetallic compounds, and others materials of interest. Materials are characterized and modified using a wide range of techniques, such as lasers, spectrometers, xrays, and optical devices. Materials are often synthesized, tested, and analyzed. Work is conducted in many facilities, such as LANSCE, the Ion Beam Materials Science Laboratory, the Energetic Neutral Beam Facility, and the National High Magnetic Field Laboratory, and small laboratories, using a vast array of equipment and materials. Custom materials and commercial components are frequently integrated to produce new instruments or materials for specific industrial and military applications.

LANL conducts a wide range of basic science on the characteristics of materials and their behavior under varying conditions. The basic science is frequently translated into applications for industry, education, and government agencies.

3.1 Automation and Robotics Research and Development

Researchers develop automated and robotic systems (such as mills, lathes, etc.) in support of the stockpile stewardship programs and other applications. These systems increase worker productivity, reduce human exposure to hazardous situations, and minimize overall waste production. Prototypes are developed and tested in nonradiological laboratories, then transferred to radiological and nonradiological facilities throughout the DOE nuclear complex. Personnel design and produce parts on a small scale, assemble and integrate mechanical and electrical components, operate and integrate systems, and test prototype instruments on nonhazardous materials. This research involves:

- Parts design and small-scale production using hand tools and machine tools in existing laboratories and machine shops.
- Mechanical assembly and integration of robotic and other mechanical systems. Personnel use cranes, hand tools, power tools, ladders, and other equipment to accomplish this task.
- Electrical assembly. Integration, and testing of electrical systems used within the instruments.
- System operation and integration, which includes system operation, including testing algorithms, and other operational issues.
- Proving, in which a variety of prototype instruments (such as mills, lathes, etc.) are tested on lumber, cardboard, and other nonhazardous materials.

Personnel use a variety of materials and equipment to construct the automated and robotic systems. These include, but are not limited to: chillers, compressors, induction power equipment, radiofrequency generators, heat exchangers, heating equipment, hydraulics, lasers, leak detectors, machine shop equipment (bench saws, drills, grinders, lathes, welders, hand tools), forklifts, cranes, motors, electronic equipment, low-power X-ray equipment, epoxies, wood, cardboard, and solder.

3.2 Electronic Systems Fabrication

Electronic systems are designed, developed, tested, and evaluated for industrial, academic, and federal agency applications. These systems control, and communicate with, many different apparatuses, such as remote handling systems, radiofrequency systems, lasers, experimental devices, surveillance equipment, alarm and safety equipment, measurement systems, and many others. Electronic systems also monitor performance, control operating parameters, serve as sensors in optics and other equipment, and serve other similar functions.

Personnel assemble electronic modules into these various systems. Electronic modules are typically obtained from a commercial vendor; however, LANL conducts some design and prototyping of electronic modules in existing facilities. The control and communications systems are integrated with various apparatuses and software is written to operate the system. System integration is often conducted at the facility contracting the work. Personnel follow hazard control plans and wear any appropriate personal protective equipment. Waste is disposed of according to facility procedures.

3.3 Antenna and Pulse Power Outdoor Test Range Facility

The Antenna and Pulse Power Outdoor Test Range consists of a 1400-acre facility used to support Department of Energy (DOE) and Department of Defense (DoD) testing requirements for a variety of military and industrial equipment. Many test programs have been completed for the DOE nuclear weapons effects testing program, the Army, Air Force, and Navy. The facility is used for open air testing and field development of very-high-power radiofrequency (RF) and high power microwave (HPM) sources and antennas. In addition, specialized equipment for diagnostic measurements on RF and HPM tests and experiments is designed, constructed, and tested.

The facility is authorized to free-space radiate at very high powers, up to 1.25 gigawatts in the frequency band of 0.02 gigaHertz to 2.0 gigaHertz. The overall authorized high power radiating frequency range is 20 megaHertz to 10 gigaHertz (in the range of radiofrequency waves and microwaves in the electromagnetic spectrum). The facility has a number of transmitter locations to simulate various configurations of illuminations and ground planes. The largest test position is one kilometer long (over ground) and extends an additional three kilometers in air. The range area is controlled to a distance of eight kilometers within the facility's boundaries. A number of high power sources and a variety of field diagnostic equipment are used, as well as analytical capabilities. Controlled explosions (typically using 10 to 100 pounds of explosives) are used to generate some electromagnetic pulses. Antenna design and fabrication is conducted within laboratory space at TA-49.

3.4 Small-Scale Basic Laser Science Applications

Small-scale research and development projects and small-scale pilot projects in the fields of basic and applied chemistry use traditional analytical instrumentation combined with lasers. Some researchers study the kinetics of chemical processes and the rates of energy transfer processes, while others develop ways to identify and/or quantify trace materials such as contaminants or small quantities of radioisotopes. In some projects, personnel research and develop client-specified unique laser instrumentation and/or applications. They research ways to identify and quantify various hazardous or toxic materials in the soil, water or air on or near DOE facilities.

Researchers develop and test unique lasers as specified by clients with specialized application needs, and they develop and confirm innovative, client-specified laser applications. Research is conducted in the areas of high-temperature/high-pressure fluid chemistry, materials processing and characterization, chemical kinetics, spectroscopic characterization, chemical diagnostics, and mass spectrometry diagnostics. Scientists investigate electroweak interactions in nuclei and apply optical trapping techniques to nonproliferation issues.

Most of the projects are conducted in a laboratory setting within existing facilities requiring no major modifications. A few of the projects, such as remote sensing of environmental phenomena, are conducted outdoors.

The following activities are examples of small-scale research and development projects and small-scale pilot projects that are carried out in existing facilities and conducted to verify a concept before demonstration actions. Each project generally continues for two years or less. Some of the projects use traditional analytical instrumentation and lasers in new ways by:

- combining two methodologies into one instrument;
- developing field-usable instruments for measuring real-time samples by modifying existing instrumentation and or procedures;
- developing new sampling techniques such that current analytical technologies may be used for the detection and/or quantification of chemical constituents at lower levels or in the field for real time analysis;
- developing new uses for existing analytical instrumentation;
- integrating existing analytical instrument with lasers to develop one instrument in order to facilitate field-use, remote sensing and real-time application, where appropriate; and
- demonstrating unique laser propagation processes such as laser filamentation.

Many of these projects attempt to develop real-time and or field-ready instruments capable of identifying and/or quantifying environmental contaminants or naturally occurring phenomena in air, water, or soil on and around DOE facilities. Portable instruments used in the field for real-time analysis offer considerable cost savings immediately, as well as the intangible benefits of speedy analyses, and personnel safety and protection. Remote sensing of environmental contaminants offers many of the same benefits, including time savings and personnel safety where identification of a contaminant occurs with little or no human exposure. Often, these projects are performed in conjunction with other national laboratories, government agencies or universities.

For example, lasers may be used to scan a contaminated area's atmosphere horizontally, vertically, or three-dimensionally to induce an optical signature of a molecule from scattering, absorption or fluorescence, or from a Raman-shift effect. The resulting optical signature identifies its unique molecular origin, leading to identification and possible quantification. When used in conjunction with other analytical instrumentation, the new combined instrument may be capable of identifying more environmental contaminants than could be identified with each instrument alone. Also, some lasers have a long range and are particularly suited to real-time field analysis and/or remote sensing analytical capabilities.

This document also covers research and development of unique lasers or unique laser applications as directed by clients (including industrial, commercial, military or academic institutions) for the client's specialized application. These projects involve designing one-of-a-kind lasers as specified by a client for their unique application. Personnel build to suit the specifications of the client, then perform in-laboratory testing and verification of the applicability of the laser. The development of these unique lasers may involve modifications to existing lasers or a completely new design. The lasers may be used for the ultra-sensitive detection of radioisotopes. Often these projects could involve joint research efforts with commercial, military and/or academic institutions.

Many of the projects covered under this document involve analytical instrumentation, much of which is currently used at LANL. Examples of the types of instruments that may be involved in projects covered by this document include, but are not limited to:

- inductively coupled plasma mass spectroscopy instruments
- radiation detectors (non-ionizing)
- gas chromatographs
- light detecting and ranging (lidar) systems
- laser ablation coupled plasma spectrometer
- fiber optic sensors
- near infrared communication diode laser sensors

- Fourier transform infrared absorption spectroscopy
- ultraviolet/visible/infrared absorption spectroscopy
- atomic absorption spectroscopy
- mass spectrometers
- magneto-optical traps

Some of the projects use lasers that are available commercially and other projects develop customized lasers. Many of the projects require pulsed lasers to obtain measurements within a short time span. The three basic types of lasers that are used include:

- ultraviolet excimer lasers,
- infrared and visible: gas, solid state, dye, and diode lasers, and
- non-linear optical devices operating in the ultraviolet, visible, or infrared spectral regions.

Personnel follow hazard control plans and/or radiation work permits when operating lasers and other equipment; they wear appropriate personal protective equipment, such as safety glasses and lab coats. All necessary engineering controls, such as warning lights and alarm systems, shielding, and door interlocks, are installed prior to beginning operations. A number of different chemicals and materials are used for these projects, including, but not limited to ethanol, acetone, phenol, methanol, ethylene glycol, cyclohexane, nitrogen, helium, and laser dyes. Very small quantities of radioactive isotopes are used; exposure would be kept as low as reasonably achievable (ALARA). All chemicals are stored in appropriate storage cabinets. Waste is disposed of according to established facility procedures. None of the projects included in this document increase air emissions above permitted levels.

Cultural resource and biological resource specialists review outdoor tests and projects to ensure protection of these resources. Some activities could be subject to standard U.S. Fish and Wildlife Service seasonal restrictions or operational limitations. Mitigation measures are followed.

3.5 Industrial Hygiene Research and Development

LANL conducts industrial hygiene-related research and development activities that anticipate, recognize, evaluate, and control health and safety hazards in the workplace. Much of the industrial hygiene R&D work conducted by LANL includes design and testing of respiratory protection and other personal protective devices. The types of devices designed and tested include respirators, respirator cartridges or canisters, protective suits, self-contained breathing apparatus, and other similar equipment.

Personnel construct respirators, canisters, and other apparatus using commercially available equipment and components or components specially fabricated in LANL shops. After constructing or obtaining commercial equipment, the respirators or other equipment are tested for efficiency, breakthrough time, and other parameters. Equipment is tested in a variety of ways. Personnel test respirators, cartridges, and other equipment by using either nonhazardous or hazardous materials, such as acid vapors. Only small amounts of acids or other materials are used each day. Some vapors may be released from the testing equipment. These vapors are contained within a glovebox, greatly diluted with air, then vented through a fume hood. Other materials are also used to conduct this work, including, liquid air (made by condensing gaseous air to liquid, or mixing liquid nitrogen and liquid oxygen), cryogens, glues, acids and other chemicals, activated carbon, and other materials.

3.6 Sensor Research and Development

LANL develops sensitive and fast sensors and imaging systems for a variety of weapons and nonweapons applications, including “smart” weapons and tracking systems. These sensors are also used for high speed data acquisition and imaging. Researchers test the sensors and construct imaging systems around them. These activities are conducted at TA-3, Building 216.

Researchers use a variety of equipment to develop these sensors and imaging systems, including computers; general laboratory equipment such as oscilloscopes, voltmeters, arbitrary function generators, radiometers, signal amplifiers, image monitors, optical light sources, etc.; high-voltage power supplies; commercial and in-house fabricated charge coupled device cameras; commercial image intensifiers; a Class IV laser; hand tools, such as screwdrivers, pliers, wire strippers, etc; and soldering irons. They use a variety of materials to assemble components, including solder, alcohol, sealant, solvent flux remover, immersion oil, silicon rubber, solder kits, heat sink compound, spray paint, and other similar materials. Researchers conduct all work in existing laboratories requiring no major modifications and follow all hazard control plans and/or standard operating procedures. They wear personal protective equipment as needed.

3.6.1 Radiation Monitoring Techniques

Researchers develop and test techniques and systems for nondestructive assay (NDA) measurements on nuclear and hazardous materials. Radiation monitors are also developed and tested. Personnel conduct conceptual research, engineering, implementation, and training related to NDA measurement, instrumentation, and analysis.

Nondestructive assay measurements work by detecting and analyzing the neutrons or gamma rays that nuclear materials emit. The analysis could include either active or passive techniques. In active techniques, the nuclear materials are bombarded with neutrons or gamma rays; the neutrons or gamma rays given off in response are then detected. The identity and quantity of the nuclear material are then determined by analyzing the energies and intensities of these neutrons or gamma rays. Calorimetry, a typical passive technique, provides the most accurate NDA method; it involves measuring the heat generated by plutonium and tritium materials. When calorimetry is combined with gamma isotopics, the mass of the material can be accurately measured.

Personnel design, fabricate, and install NDA instrumentation for safeguards organizations throughout the world. They also further develop both active and passive techniques to more accurately measure nuclear materials. LANL shops fabricate most small mechanical parts used for these instruments; off-site machine shops fabricate larger mechanical items. LANL personnel also design and build most of the custom electronics, although external sources may fabricate some electronics parts. LANL personnel design, assemble, test, calibrate, develop software, and verify the performance of the instrumentation.

Most of the instrumentation consists of printed circuit boards, electronics equipment, and mechanical assemblies; it is constructed using a variety of materials. These include, but are not limited to, aluminum, stainless steel, nickel, cadmium, lead, tungsten and other metals, Kel-f, Teflon, nylon, circuit board material, polyethylene, compressed and flammable gases, solvents, and other similar materials. A variety of tools and instruments are used to assemble, calibrate, and test the instrumentation. These include, but are not limited to, small hand tools, soldering irons, welding equipment, exhaust hood, milling machines, lathes and similar machine shop equipment, general laboratory electronic instruments such as oscilloscopes, high- and low-voltage power supplies, encapsulated radioactive sources, environmental test chamber, neutron generators, high-voltage x-ray sources, and computers.

3.6.2 Physical Detector Research and Development

LANL develops a wide variety of detectors for use in physical science research that are capable of identifying ionizing radiation, X-rays, photons, electrical and magnetic fields, chemicals, gases, pressure, gravity, explosives, biological materials, dense materials, and other phenomena. The detectors consist of a medium that responds to the primary condition of interest, such as liquid (e.g., mineral oil), solid (e.g., crystalline materials), or gaseous (e.g., isobutane) materials, in a support housing for mechanical/electrical stability, coupled to electronic circuitry and assemblies. The proposed project entails materials characterization, fabrication and testing of detectors, and support capabilities.

3.6.2.1 Materials Characterization

Prior to developing a detector, researchers characterize physical media so that they understand the nature of its response for a given stimulus. This characterization is conducted in laboratories and shops using a variety of chemical, electrical, and other technologies commonly developed in research and development settings at LANL.

3.6.2.2 Fabrication and Testing of Detectors

Researchers design, construct, and test a variety of different detectors, including, but not limited to: ultra-low light imaging detectors, ionizing radiation detectors, optical detectors, chemical detectors, and others. The detectors use a number of different technologies involving other instruments and materials, including, but not limited to: lasers, microwaves, radiofrequency fields, ionizing radiation from sources and machines, chemicals and other liquids, crystals and other solids, and gases. Many custom and commercially-available materials are used to construct the various detectors, including, but not limited to: electronic circuits, photo-reactive materials, thin films, crystalline compounds, scintillating solids and liquids, glass, plastic, gases, liquids, metals, cryogens, and other materials. After construction of a detector, outdoor testing may be conducted where range or environmental conditions are a necessary part of the development or testing. No cultural resources or biological resources are impacted by any outdoor testing activities.

3.6.2.3 Support Capabilities

Support facilities connected with the above research require special training for employees. Access to radiological materials and facilities, and work with specific materials often require site-specific training. Existing machine shops, electronics shops, and fabrication areas are used. Only authorized personnel are permitted to work in these areas. Small amounts of solvents and acids are used for cleaning. The materials and chemicals used in detector development include acids (hydrochloric, nitric, etc.), solvents (methanol, acetone, ethanol, etc.), compressed gases (toxic and flammable), liquid gases (liquid nitrogen, etc.), and toxic metals (beryllium, cadmium, lead, nickel, silver, etc.). These are used in small, research laboratory quantities. Other tools, instruments, and materials used in research, development, assembly, and testing include, but are not limited to: general laboratory electronic instruments, high voltage power supplies, microwave/radiofrequency generators, encapsulated radioactive sources, nuclear particle accelerators, network analyzers, vacuum systems, clean rooms, cryogens, optical glasses and coatings, deposition chambers, photography equipment, sputter systems, glove boxes, transducers, bench-scale analytical instruments, spectrometers, spectrum analyzers, and lasers.

3.6.3 Advanced Image Sensor Research and Development

LANL develops sensitive and fast sensors and imaging systems for a variety of weapons and nonweapons applications, including “smart” weapons and tracking systems. These sensors are also used for high speed data acquisition and imaging. Researchers test the sensors and construct imaging systems around them. These activities are conducted at TA-3, Building 216 and other LANL facilities.

Researchers use a variety of equipment to develop these sensors and imaging systems, including computers; general laboratory equipment such as oscilloscopes, voltmeters, arbitrary function generators, radiometers, signal amplifiers, image monitors, optical light sources, etc.; high-voltage power supplies; commercial and in-house fabricated charge coupled device cameras; commercial image intensifiers; a Class IV laser; hand tools, such as screwdrivers, pliers, wire strippers, etc; and soldering irons. They use a variety of materials to assemble components, including solder, alcohol, sealant, solvent flux remover, immersion oil, silicon rubber, solder kits, heat sink compound, spray paint, and other similar materials. Researchers conduct all work in existing laboratories requiring no major modifications and follow all hazard control plans and/or standard operating procedures. They wear personal protective equipment as needed.

3.7 <u>Space and Atmospheric Instrumentation Research and Development</u>

Flight hardware, atmospheric instrumentation, satellite instrumentation and small satellite systems are developed at LANL. Much of this instrumentation is used for remote sensing applications, such as nonproliferation, detection of nuclear explosions, climate studies, and environmental measurements. Types of instrumentation typically developed include optical and infrared remote sensing instruments; x-ray, gamma-ray, neutron, alpha particle, radiofrequency, and energetic particle instruments; astrophysical instruments for conducting studies of the atmosphere, ionosphere, magnetosphere, and solar wind; and other instrumentation for deployment on satellites or other atmospheric testing vehicles. Outdoor experiments are often conducted as part of this research, and involve measuring fluctuations in the atmosphere and ionosphere and calibrating satellite receivers that are in orbit. Outdoor experiments are conducted at various locations around Los Alamos, the United States, and at other locations around the world.

3.7.1 Hardware Development

Researchers design, fabricate, and then deploy flight and satellite instrumentation and small satellite systems. After deployment, they collect and analyze data. LANL shops fabricate most mechanical parts and LANL personnel design and fabricate electronics used in the instrumentation. Some parts may be fabricated by external sources. Personnel design, assemble, test, calibrate, and verify the performance of instrumentation and small satellites.

Most of the instrumentation consists of printed circuit boards, photodiodes, and electronics equipment and are constructed using a variety of materials. These include, but are not limited to, aluminum, other metals (such as copper, nickel, and stainless steel), Kel-F, Teflon, nylon, circuit board material, ceramic, glass, Viton, polyurethane coatings, epoxy, compressed and flammable gases, solvents, and other similar materials.

A variety of tools and instruments are used to assemble, calibrate, and test the instrumentation. These include, but are not limited to, small hand tools, soldering irons, clean bench and exhaust hood, general laboratory electronic instruments (such as oscilloscopes), experimental vacuum chambers and cryogenic vacuum chambers, high voltage power supplies, beam chamber, light machine shop, microwave ion source, encapsulated radioactive sources, computers, and high-voltage pulsed x-ray sources. Testing of the instrumentation and satellites may be conducted at other facilities, such as other DOE, NASA, NIST, and university facilities. Instrumentation is deployed at other facilities.

3.7.2 Outdoor Experiments

LANL uses some instruments to measuring fluctuations in the atmosphere and ionosphere. LANL also calibrate satellite receivers that are in orbit. These experiments are conducted at various locations around Los Alamos, the United States, and at other locations around the world. Outside of the U.S., a cooperative agreement between the reigning sovereignty would exist; the sovereignty would be a participating entity allowing the researchers to enter their country and carry out work in their country. The countries possible for field sites include Australia, Canada, Caribbean Islands (such as Aruba, St. Thomas, and Guadeloupe), French Guinea, Ivory Coast, Marshall Islands, Norway, Peru, and various British possessions.

In the U.S., work is conducted at privately owned facilities, such as motel parking lots, farms, etc., and in locations owned or operated by other government institutions, such as NASA, U.S. Coast Guard, etc. When conducting work outside LANL boundaries, personnel obtain written permission of the landowner (either private, municipal, county, or state) prior to setting up equipment and conducting experiments. At other federal government institutions, a formal agreement is made between the parties involved prior to performing any outdoor experiments.

Common field experiments involve measuring background fluctuations in the atmosphere and ionosphere, such as measuring radiation emitted from lightning. The techniques employed involve probing the atmosphere or ionosphere with electromagnetic (EM) waves. The EM waves are generated in a variety of ways, including using commercial High Frequency (HF) and Very High Frequency (VHF) transmitters in the range of 10 to 500 watts. Existing space- and ground-based radio transmitters are also used for signals. The antenna masts holding this instrumentation are commercially available. Other instrumentation, such as oscilloscopes, scintillators, photo counters, and etc, are also used. Optical experiments are conducted at these field sites and involve commercially available optical systems on a LANL-designed and built tracking mount.

LANL personnel also conduct other outdoor projects, including using instrumentation to calibrate satellite receivers in orbit. An antenna facility at LANL is used to conduct some of this work. The antenna is a large dish (approximately nine meters in diameter) that transmits energy primarily in the 50 to 150 megahertz frequency range. Pulses of energy are recorded on the satellite in orbit, and then sent back to the antenna in Los Alamos. Other antennas and equipment, and modifications to that equipment, may also be used. Encapsulated (sealed) radioactive sources are used for calibrating instrumentation.

Prior to conducting outdoor experiments, personnel obtain any necessary FCC licenses for transmitting sites. They also obtain private landowners' or government agencies' permission, or sign a cooperative agreement with the sovereign nation. All local, county, state, and federal requirements and laws are followed. During transportation of any transmitting device, applicable local, state, and federal requirements are followed.

3.8 <u>Material Science Research and Development</u>

3.8.1 Materials Characterization

Researchers study various materials to determine molecular structure, intrinsic defects within the material, defects introduced by the environment or radiation, thermal conductivity, thermal expansion, nuclear spin magnetization, electronic magnetization, resistance, heat capacity, and other properties. A number of different materials are studied, including non-metallic materials (such as ceramics, crystals, amino acids, and polymers); transition metals; transition metal oxides; and transition and rare earth metal intermetallic compounds. These materials may be mixed compounds, or layered structures, in powder or crystalline form. This research also includes developing techniques for improved sensitivity of equipment in detecting these responses.

Samples are prepared, as necessary, by cutting, shaping, pressing, and grinding using wafering and wire saws, polishing tables, sonic baths, and other tools and equipment. The samples are then characterized using photon sources (such as mercury pen lamps, ultraviolet lights, X-ray sources, and other optical equipment); fiber optic laser interferometry; nuclear magnetic resonance; and other experimental apparatus that subjects the sample to controlled environments, including cryogenic conditions and magnetic fields.

3.8.2 General Optical Characterization and Calibration

Researchers characterize optical components used for a variety of applications, such as measuring solar radiation; measuring the reflectance from computer chips and wafer samples; measuring different spectral wavelengths resulting from explosives tests; measuring low-light level signals in darkened conditions; selectively measuring narrow frequencies in a light signal; monitoring motion (motion detection); and other similar light detection applications.

Personnel measure reflectance and transmission (or absorbance) of light. Using a variety of light signals (different lamps with different wavelengths, such as visible, infrared, ultraviolet and vacuum ultra violet), they shine the light onto the component and use calibrated detectors and other measuring devices (such as reflectometers) to measure the reflectance or transmission of the light. They use low power lasers to align the light signal onto the detector being characterized.

3.8.3 Ion Beam Materials Science

Researchers characterize and modify surfaces through the use of ion beams at the Ion Beam Materials Science Laboratory (IBML) at TA-3, Building 34. The main experimental equipment includes a 3 MV tandem accelerator and a 200 kV ion source implanted together with several beam lines. A series of experimental stations are attached to each beam line. These include the Nuclear Microprobe, Surface Modifications, Ultrahigh Vacuum Chamber, and General Purpose Experimental chambers.

3.8.3.1 Nuclear Microprobe

The microprobe is used for experiments on geological samples to obtain nanoampere currents in micro-diameter sizes. Examples include geochemical fractionation on rare earth elements in meteorites and studies of carbon in terrestrial minerals. Analysis techniques used include Rutherford Backscattering Spectroscopy, nuclear reaction analysis, and particle-induced x-ray emission.

3.8.3.2 Surface Modifications

Surface modification experiments are performed in either the implanter end station or in the surface modification chamber, at temperatures from 80K (cold) to 800°C (hot). Experiments performed include adhesion of metallic films to polymer and ceramic surfaces, ion- and laser-inducing mixing and radiation-induced phase transformations, and surface treatments for abrasion and corrosion resistance, and similar improvements.

3.8.3.3 Ultrahigh Vacuum Chamber

This experimental station consists of two connected ultra-high vacuum chambers, with a variety of surface techniques available, such as x-ray photelectron spectroscopy, Auger electron spectroscopy, ion-scattering spectroscopy, Rutherford Backscattering Spectroscopy, elastic recoil detection, and others. The chambers are used to study thin film interfaces in metal alloys and metal semiconductor systems.

3.8.3.4 General Purpose Experimental Chamber

This chamber is used for x-ray, gamma-ray, nuclear reaction analysis, Rutherford Backscattering Spectroscopy, and elastic recoil detection techniques, as well as for high-energy implantation with beams from the tandem accelerator.

3.8.3.5 Plutonium Experimental Chamber

This experimental chamber is a small stainless steel vessel that contains both the sample and a detector. A vacuum gate valve on the vessel bolts onto another existing chamber and beam line at the IBML. Analysis techniques used include Rutherford Backscattering Spectroscopy with the ion beam from the accelerator and a detector in the small chamber. Test samples consist of small test coupons of plutonium (Pu)-contaminated stainless steel. The amount of surface contamination varies from a few monolayers of Pu to no detectable Pu. LANL Nuclear Materials Technology (NMT) personnel load the samples into the chamber; the samples are never exposed to air or removed from the small vessel.

A variety of materials are used to conduct this research, such as liquid nitrogen and helium, sulfur hexafluoride, epoxies (for binding samples), small quantities of many metals (for ion sources), and alcohol (for cleaning equipment). Thin film erbium hydride samples are non-destructively tested at the IBML. The amount of tritium, deuterium, and hydrogen within the targets are analyzed using the ion beam. The targets have a maximum activity of 1 Curie and up to 3 samples are run at a time.

3.8.4 High Magnetic Field Research and Development

LANL conducts research using ultra high magnetic fields in the National High Magnetic Field Laboratory (NHMFL) at TA-35, Building TSL-125. The NHMFL is used by LANL, other governmental, industrial, and academic personnel. The great majority of experimental research conducted at the NHMFL is in the fields of materials science and condensed matter physics. Magnets currently in operation at the NHMFL have maximum magnetic field intensities ranging from 20 to 300 Tesla for several microsecond to several millisecond intervals. These include both superconducting magnets and pulsed power capacitor-driven magnets. Very small samples are studied, and include plutonium (Pu) 239, Pu-242, depleted uranium 238, thorium compounds, cerium, high-temperature superconductors, other metals and semi-conductors, and other materials.

Magnets are contained within enclosure rooms or surrounded by fragment barriers. The 300 T magnet is contained within an airtight enclosure room in a large high bay. Engineering controls, such as radiation air sampling and alarms, redundant interlocks protecting energized electrical equipment, HEPA filtration, and oxygen monitors, are used to limit access to high magnetic field areas and protect personnel from ultra high magnetic fields. Pulsed magnetic fields are generated using high voltage stored energy systems (non-PCB capacitor banks enclosed within cages). Experimental areas and control rooms for data acquisition are also included within the facility.

3.8.5 Ultra-High Strength and High Energy Density Materials Research and Development

LANL researchers investigate, evaluate, and demonstrate new ultra-high strength materials and very high energy density materials. Ultra-high strength materials are produced using a variety of metals (such as copper, silver, or aluminum) encapsulated in glass, which are then heated and drawn into small wires. Thin-film samples of high energy density materials are synthesized under non-equilibrium conditions. Both materials are characterized by measuring the material composition, chemical structure, mechanical and thermal properties, and energy content and release of these materials.

3.8.5.1 Ultra-High Strength Materials

LANL researchers conduct basic research in ultra-high strength materials. They produce new ultra-high strength materials then use indentation plasticity methods to analyze these materials. Researchers conduct detailed studies of the interfaces in high strength materials and hope to develop new theoretical models of plasticity with strength levels close to the theoretical strength of solids.

The ultra-high strength materials are produced using a variety of metals (such as copper, silver, aluminum, nickel, niobium, etc.) and glass. Small glass tubes are filled with metal bars, then heated using either a spot lamp that concentrates light into a very small area [approximately 6 millimeters (mm)] or an induction heater. After the metal has melted and the glass is soft, the composite is drawn to form wires of 100 mm or less. The glass adheres to the metal, thereby coating it. The wire products (metal core plus glass coating) act as conductors (the glass is used for insulation). A variety of material property tests are conducted on these materials, including tensile tests, microhardness tests, conductivity tests, etc. Electron microscopy examination of the wires is also conducted.

3.8.5.2 High Energy Density Materials

LANL investigates, evaluates, and demonstrates new, very high energy density materials based on novel energy storage concepts. Non-equilibrium conditions are used to produce milligram quantities of high energy density materials. The materials synthesis effort uses radiofrequency power supplies, vacuum containers, vacuum pumps, mass flow controllers, down-stream pressure control and direct-current high voltage power supplies. These materials are then characterized by measuring their material composition, chemical structure, mechanical and thermal properties, and energy content and release. These activities use ion beam scattering, infrared spectroscopies, a variety of calorimetric techniques, electron spectroscopies, mass spectroscopy, and optical spectroscopies.

3.8.6 X-Ray Tomography and Ultrasound Testing

LANL researchers X-ray [using computed tomography (CT)] and ultrasonically analyze various samples. CT equipment is used to generate three-dimensional images, detect cracks or flaws, generate three-dimensional density maps, or precisely locate parts or features within an object. The ultrasonic equipment is used to detect cracks, voids, and inclusions, and density variations. It can also be used on samples that require small resolution. Ultrasonics can also be used to inspect surface characteristics and bulk properties (such as porosity) of a sample. Researchers combine the x-ray computed tomography and ultrasonic methods to see if data fusion techniques improve the evaluation of the sample.

A variety of samples and specimens are analyzed, including sand, soil, plastics, foam, mock high explosives, composite materials, pressure vessels, or other nonradioactive samples. Researchers also analyze specimens containing naturally occurring radioactivity (NORM), such as rocks, soils, etc. The specimens vary in size, depending on the equipment being used. The CT equipment can analyze objects up to 10 inches in diameter by 15 inches high, while the ultrasonic equipment can analyze up to either a 12 inch by 12 inch flat plate or a 10 inch by 12 inch cylinder. Samples come from a number of different sources and are either shipped through traditional methods, or hand-carried by personnel requesting the tests. The samples are delivered to LANL, then shipped or picked up when analysis is complete. Samples containing naturally occurring radioactivity are transported according to Department of Transportation and DOE regulations.

3.8.7 LANSCE Materials Science Research and Development

Materials science research at the Los Alamos Neutron Science Center (LANSCE) encompass a wide range of research topics, including materials science, engineering, condensed-matter physics, geoscience, chemical science, biological sciences, and fundamental neutron science. Researchers conduct a wide variety of activities, including, but not limited to: viewing and studying defects in light materials that lie inaccessibly beneath heavy materials, well beyond the range of x-rays; measuring the behavior of materials under extreme conditions, such as high temperature or pressure; studying the interior of materials to obtain either microscopic or structural information; and imaging hydrogenous material, such as water or oil, in parts or components to deduce lifetimes, corrosion, safety, and quality control issues.

Both neutron- and proton-induced experiments are conducted. Low-energy neutron-induced experiments are conducted at Target 1 in the Lujan Center and high-energy experiments are conducted at WNR Target 4. Low-current proton-induced experiments are conducted at WNR Target 2 and high-current experiments are conducted at Area A.

In a typical experiment, sample material is placed in a target chamber that has been customized to produce specific kinds of analytical results. A beam of protons or neutrons is then directed onto the target and the resulting scatter of particles is analyzed. Sample materials vary widely and could include radioactive targets (actinides, etc.), heavy metals, and gases (such as deuterium, tritium, and hydrogen).

At times, explosive materials are studied and may also be used to create high pressures or to drive changes in other materials. The beam and target environments are varied to produce specific conditions under which sample materials are studied. These conditions include high and low temperature, high and low pressure, vacuum, low oxygen conditions, presence of hazardous gases, etc. A variety of equipment and materials are used to create these conditions, such as vacuum pumps, furnaces, cryogenic systems, rotors, explosives, toxic gases, etc. Lasers, spectrometers, and a variety of electronic detectors are used for diagnostic measurements.

3.8.8 Energetic Neutral Beam Facility Research

The Energetic Neutral Beam Facility, located at TA-46, Building 31, consists of two neutral beam sources, and is used by personnel from other federal agencies, universities, and industry. The beam sources have diagnostic capabilities that include mass spectrometry and time-of-flight. The primary activity at this user facility is to investigate surfaces, specifically gas-surface interactions, including scattering and/or reaction mechanisms. Personnel also conduct some thin film work and detector studies using sealed sources.

The first beam source produces continuous high energy atomic beams with energies from approximately 1 to 5 electron volts (eV). This high-energy source is used to passivate surfaces and grow semiconductor materials. The source produces either a beam of atomic oxygen or atomic nitrogen inside a vacuum chamber. The atomic beam is directed upon surfaces, such as radiation detectors, where it is used to initiate chemical reactions. A Class 4 laser is a fundamental piece of equipment for this source and the beam produced by this laser is contained within a Class 1 container.

The second beam source is a continuous medium energy molecular beam source. This source is used to measure momentum transfer coefficients for gas-surface interactions encountered in rarefied flow regimes, such as low earth orbit. These measurements aid in the design of spacecraft. The coefficients are determined by measuring the force exerted on a surface by a molecular beam. The force is then measured using a torsion balance, which is made from aluminum. The molecular beam source is made from materials such as nickel, tungsten, or graphite.

Other equipment and materials, in addition to those already listed, are used, including gases (such as hydrogen, nitrogen, helium, carbon dioxide, carbon monoxide, oxygen, argon, xenon, and neon), solvents (such as alcohol and acetone), XPS surface analysis apparatus (used for diagnostics), vacuum hardware, vacuum pumps, and sealed (nonaccountable) radiation sources. Personnel follow hazard control plans and/or standard operating procedures when operating the laser and other equipment, and wear any necessary personal protective equipment, such as safety glasses. All necessary engineering controls, such as shielding for the laser, are installed prior to beginning operations.

4.0 Basic and Applied Chemistry and Electrochemistry

4.1 Basic and Applied Chemistry

LANL's basic and applied chemistry research program brings together multidisciplinary capabilities for the study of a wide range of topics, including actinide and fission product chemistry, inorganic and organometallic chemistry, catalysis, surface chemistry, surface analysis, radioisotope production and distribution, chemical and electrical engineering, detection technologies, nanoscience and nanotechnology, analytical chemistry, environmental chemistry, nuclear and radiochemistry, physical chemistry, chemical and nuclear physics, and optical and vibrational spectroscopy.

Many organizations at LANL contribute to chemistry and chemical research. These organizations are responsible for a variety of different projects, funded through the Department of Energy (DOE), Department of Defense (DoD), National Institutes of Health (NIH), Laboratory Directed Research and Development (LDRD), and others. Studies conducted within LANL have numerous internal and external collaborations that provide flexibility in direction and scope. Collaborations are internal to groups and divisions, between various divisions at LANL, and with external collaborators such as visiting scientists.

4.1.1 Programs

A variety of programs exist in support of nuclear weapons, non- and counter-proliferation and homeland security, isotope science, applied energy and nanoscale science and engineering.

4.1.1.1 Nuclear Weapons

This program focuses on planning the next generation of nuclear facilities for safely handling actinide metals and their compounds. Several experimental programs are conducted, for example; hydrotesting support, surveillance, and experimental work with other LANL personnel in support of the enhanced surveillance program and directed stockpile work.

4.1.1.2 Non- and Counter-Proliferation and Homeland Security

LANL researchers study methods to detect, prevent, assess, and respond to nuclear, chemical and biological threats. In partnership with other LANL personnel, chemistry personnel develop technologies that would enhance national as well as global security. Work is conducted for a number of federal agencies.

4.1.1.3 Isotope Science

This program focuses on the production of medical radioisotopes and the development of a national isotope strategy with other DOE laboratories to rejuvenate the United States isotope production capability and encourage research needed to optimize isotope production and radiopharmaceutical development. The ultimate goal would be to develop a new program in molecular nuclear medicine at LANL.

4.1.1.4 Applied Energy

LANL researchers study novel methods of hydrogen production, storage, and utilization; carbon measurement, management, and carbon dioxide sequestration; homogeneous and heterogeneous catalysis; combinatorial methods of screening and analysis; advanced chemical processing techniques; and nuclear technology and applications.

4.1.1.5 Nanoscale science and engineering

This program focuses on nanoscale chemical synthesis and processing, chemical kinetics and molecular dynamics, and instrumentation and diagnostics. Personnel fabricate and study new materials and examine unique phenomena that occur at the nanometer scale. They would develop spectroscopic probes to examine optical and electronic behavior in these systems, and novel processing methods to tailor surfaces.

4.1.2 Operations

There are many different operations conducted within the chemistry programs at LANL. Some of these operations are specific to one group, but many are conducted by researchers in several groups and divisions. The types of operations conducted include instrumental analysis and spectroscopy, synthetic chemistry, materials chemistry, analytical chemistry and sample preparation, beryllium work, pressure work, radiochemistry and radiological work, biological chemistry, and explosives work. Each of these operations will be discussed, as well as the types of equipment and chemicals used in these operations.

4.1.2.1 Instrumental Analysis and Spectroscopy

These operations involve a wide range of techniques including, but not limited to, laser-induced breakdown spectroscopy (LIBS), remote sensing using LIDAR and other techniques, molecular imaging (Fourier transform infrared spectroscopy, fluorescence and Raman), elemental analysis by X-ray fluorescence, mass spectrometry analysis, fluorescence analysis, time-resolved spectroscopy, electrochemistry, solution and solid-state multinuclear nuclear magnetic resonance (NMR) spectroscopy, single crystal and powder X-ray diffraction, steady state and time-resolved laser absorption and emission spectroscopy (optical, IR, Raman), specialized multi-technique surface science instruments that include X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), secondary ion mass spectroscopy (SIMS), electron stimulated desorption (EDS), sputtered neutrals mass spectroscopy (SNMS), scanning tunneling microscopy (STM), atomic force microscopy (AFM), low energy ion scattering spectroscopy (ISS), thermal desorption spectroscopy (TDS), infrared spectroscopy (IR), and Fourier transform infrared spectroscopy (FTIR) methods, including micro-reactor chambers for in situ studies.

Various equipment is used, including all classes of lasers, gas chromatographs, high pressure liquid chromatographs, differential scanning calorimeters, thermal gravimetric analyzers, potentiostats, infrared spectrometers, fluorimeters, vacuum pumps, diffusion pumps, UV/Vis spectrometers, infrared spectrometers, NMRs, X-ray diffractometers, X-ray fluorescent instruments, scanning tunneling microscopes, mass spectrometers, ultra-high vacuum systems, evaporators, gas (both atomic and molecular species) dosers, and deposition methods that include sputtering, laser ablation, electron beam, and rf and dc discharge systems.

Many instruments do not involve the use of chemicals outside of the samples to be analyzed. Samples vary in quantity, but are typically very small involving less than 20g or 20 mL. In addition, many of the techniques are non-destructive so samples remain intact for further study. A number of different materials are used, including small quantities of hazardous chemicals and gases (such as dyes, solvents, acids, deuterium, carbon monoxide and hydrogen), gas cylinders (argon, nitrogen, and compressed air), and cryogens (liquid nitrogen and liquid helium). Bench-scale quantities are typically used, with the exception of liquid nitrogen and liquid helium. NMR spectrometers can hold up to 100 L of liquid nitrogen and 50 L of liquid helium. Approximately 50 L of liquid nitrogen and 5 L of liquid helium are used per week.

4.1.2.2 Synthetic Chemistry

Inorganic, organic, organometallic and solid-state synthetic chemistry are performed. Both known and new chemicals are synthesized. New synthetic procedures are also developed in an effort to improve synthesis and make novel materials. Synthetic chemistry is an important element in a number of research activities, including the design of ligands for binding metals; chemical kinetics and thermodynamics studies; DeNOx and environmental catalysis; heterogeneous and homogeneous selective oxidation and phase-separable catalysis; new materials for hydrogen storage; new sensors for chemical and radiation detection; tamper-resistant seals, tags, and tamper indicators; polymer-assisted deposition of inorganic films; novel chemistry in ionic liquids; design and characterization of new materials for light emitting devices; synthesis of heterogeneous catalysts including micro- and mesoporous materials; synthesis of ligands and organometallic complexes for separations and homogeneous and phase-separable catalysis; synthesis of thin inorganic films for catalysis, phosphors, piezoelectrics and optical coatings; and others. Surface modifications are also performed using solution techniques as well as solid-state methods. Materials synthesis also occurs using broad classes of techniques for deposition and surface and interfacial modifications such as evaporation, sputtering, discharges, nanoimprinting, lithography, and etching.

Various equipment is used, including cryogenic (ultrafreezing) apparatus, centrifuges (several thousand RPM to tens of thousand RPM), rough and ultra-high vacuum systems (diffusion and turbo pumps), schlenck lines, dry boxes, heating mantles, rotary evaporators, stir plates, and water recirculating units. Much of the equipment used is commercially available.

This work utilizes a broad spectrum of chemicals, including agents that are often caustic (acidic or basic), toxic, mutagenic, and/or carcinogenic. These include solvents such as dichloromethane, ether and tetrahydrofuran. Solvents used on the bench scale are less than 3 L and typically less than 500 mL. Concentrated acids and bases are used to adjust pH, prepare acid baths, for cleaning, and as reagents. Most manipulations involve less than 1 L of acid or base. Aqueous acid baths can be up to 5 percent acid and 20 L in volume. The acid baths are kept covered and are used for extended periods of up to several months before being disposed of. Reagents involve a wide range of chemicals with a variety of hazards. Reagents are generally used in small quantities of less than 300 mL or 300 g. All carcinogens and toxic chemicals are used in approved fume hoods. Solvent purification systems would be used to remove air and water from commercial solvents (such as toluene, hexane, ether, and tetrahydrofuran) in 19L quantities. These solvents are completely contained in the system and aliquots are withdrawn for synthesis.

4.1.2.3 Analytical Chemistry and Chemical Sample Preparation

Analytical services are done for a number of programs, including characterization and certification of nuclear and non-nuclear materials, radioactive waste treatment, and waste certification. Services conducted include process analytical chemistry, real-time online gas analysis, continuous particle counting and characterization, at-line solid metals analysis, online spectroscopy for chemical analysis, real-time biological and chemical detection, quick response analyses, trace element analysis, inductively coupled plasma spectroscopy (atomic emission and mass spectrometry), direct current arc emission spectroscopy, cold vapor atomic fluorescence, and ion chromatography. New analytical methods are also developed, including automated volatile and semi-volatile organics analysis, chemical analysis automation, chemical sensor development, headspace gas sampling and analysis, safe gas sampling and analysis from high pressure environments. Sample preparation varies from direct analysis on unaltered samples to microwave dissolution, acid leaching, and less common techniques involving perchloric acid or HF.

Many different types of equipment are used for these techniques, including those listed above. Other instruments used include, but are not limited to, microwaves, inductively coupled plasma instruments, carbon furnaces, BET, infrared spectrometers, UV/Vis spectrometers, and fluorescence spectrometers.

Chemicals used include the samples themselves, chemicals such as caustic acids and bases for sample preparation, and standards used in instrument calibration. A wide variety of samples are processed including solids, such as filters and soils; solutions; and gases. Perchloric acid fuming is limited to a few approved hoods. Dissolution and leaching techniques use less than 3 L of solutions. Most of the dissolutions are aqueous solutions with varying acid concentrations depending on the technique.

4.1.2.4 Beryllium Work

This work includes analysis, ligand binding, materials characterization, field sampling, fundamental beryllium chemistry, and beryllium mitigation. Most of the beryllium involves solutions, wetted solids, or one-piece solids such as coupons or articles and does not require participation in the LANL Chronic Beryllium Disease Prevention Program (CBDPP). There is a small amount of work done with beryllium solids that has the potential for airborne material. This work includes weighing beryllium solids (such as beryllium metal, beryllium carbonate and beryllium oxide; less than 5 grams per sample), and ashing of adhesive films used in sampling (micrograms of beryllium per sample).

The equipment used for beryllium work include those listed above, as well as HEPA filtered boxes used for beryllium solids that are designed to prevent the release of airborne material.

Chemicals in the fundamental beryllium chemistry are similar in nature to those used in synthetic chemistry as described above. The main additional chemical is beryllium that can be in the form of standards for ICP, concentrated stock solutions or in limited cases beryllium solids such as metal, oxide or simple salts such as beryllium sulfate. Most solutions of beryllium are less than 1M beryllium and less than 1 L. Solutions for analytical work are typically at the micromolar level. Solid manipulations are limited to less than 5 g of beryllium and are done in a HEPA filtered box. Five percent covered acid baths are used in cleaning and can be up to 20 L in volume.

4.1.2.5 Pressure Work

Operations involving pressure include surface science research, some chemical synthesis activities, catalysis research, high-pressure and high-temperature fluids research, and reactions in dense phase carbon dioxide. Most experimental work involving pressure is done at low-energy pressure (less than 20 kJ stored energy) and includes compressed gas cylinders, vacuum, and cryogenic work. Engineered certified barriers would be used as necessary. There is no additional equipment or chemicals used for pressure work than those described above.

4.1.2.6 Radiochemistry and Radiological Work

Low-level radiochemical work involves synthesis, separations, wet chemical operations, and surface analysis. Low-level radiological work is carried out in limited radiological control areas and includes surface science studies of actinide interfaces; reactivity and materials aging; and fundamental f-element chemistry, including synthesis, characterization, reactivity, spectroscopy, and thermodynamics of f-element complexes. Higher level radiological work is done in designated areas of TA-48, Building RC-1 and the CMR facility.

Low-level radiological operations involve standard wet chemical processes, including weighing, dissolving, and mixing of solutions and solids. Gram-scale quantities (less than 200 grams total) of depleted uranium (U-238) and thorium (Th-232) are used, as well as limited quantities (less than 50 grams total) of natural mineral specimens containing natural abundance uranium. Operations areas are also used as staging areas for spectroscopic examination of transuranic samples, which are limited to less than 108 dpm per sample, and are doubly contained.

Additional low-level radiological work involves X-ray diffraction of single crystals that are less than 500 µm in their largest dimension. The quantities of materials are very small, and are limited to less than 10 mg for depleted uranium, thorium, and technetium. Samples are contained in a viscous oil to prevent dispersal, and are packaged in three containers. A quality crystal is selected, mounted with a thin coating of the viscous oil on a glass fiber or loop, and frozen in place on the instrument in a liquid nitrogen vapor stream. For crystals containing beryllium (less than 5µg per crystal) or radioisotopes (237Np, 239Pu, 242Pu, 248Cm, 243Am, and 241Am; less than 5µg per crystal) a triple containment technique is used. In these cases, the crystal is coated with epoxy, placed in a quartz capillary, and the capillary coated with acrylic. The acrylic coating holds the crystal and glass in place in the event of breakage. All samples are returned to their originating laboratory for proper disposal.

In addition to the instrumentation used in other chemistry operations, counters, including scintillation counters, can be used.

Additional chemicals include radioactive materials such as 99Tc, 232Th, 238U, 237Np, 239Pu, 242Pu, 248Cm, 243Am, and 241Am at low levels. All radioactive materials would be appropriately containerized and stored.

4.1.2.7 Biological Chemistry

Biological work is limited to Biosafety Level 1 (BSL-1) work only. Biological chemistry research focuses on metal interactions with proteins, protein purification, bioremediation, and protein spectroscopy. Organisms such as bacteria and plants that fall under the BSL-1 designation are used. No live animal experimentation is conducted.

Equipment used for biological chemistry activities include gel electrophoresis and equipment as already listed above.

Bench-scale quantities of a variety of chemicals, similar to those already mentioned, are used. Additional materials used include proteins, synthetic peptides, growth media, and buffers in aqueous media. Proteins are used on the milligram scale. Up to 3 L of buffer solutions can be used at any one time.

4.1.2.8 Explosives Work

Work with explosives includes laboratory scale experiments involving known explosive materials (less than 10 gram quantities per experiment), azide operations, and use of perchlorates. Perchlorate work is limited to approved hoods and can only be done by trained workers. Work with known explosives are conducted in confined chamber and then vented; explosives work complies with building limits and is either destructive or nondestructive in nature.

Personnel follow hazard control plans and radiological work permits when conducting these operations. They wear appropriate personal protective equipment, such as eye protection, gloves, face shields, and laboratory coats. Engineering controls are used as necessary, including glove boxes, fume hoods, shielding, radiation monitors, warning lights, interlocking doors, etc. Exposure to ionizing and nonionizing radiation is kept as low as reasonably achievable (ALARA). All chemicals used are segregated and stored according to established LANL and facility protocols. All wastes generated, including hazardous, radioactive, mixed, and other wastes are properly stored in the appropriate containers, and disposed of according to established LANL protocols. For Biosafety Level 1 work, personnel use standard microbiological practices, including appropriate sterilization procedures and wearing personal protective equipment, such as gloves.

4.2 **Electronic and Electrochemical Materials and Devices**

LANL conducts research involving electrochemistry and electronic materials. Research capabilities include projects that involve the disciplines of chemistry, electrical engineering, electrochemistry, mathematics, materials science, and physics, which are teamed on a wide variety of projects contributing to the nation's defense and economic security. Specific areas of research include electrochemistry and the fuel cell program, semiconductor physics research and device development, high temperature superconductivity, electrochemical testing, general electronic materials characterization and theory, and nondestructive testing through acoustic techniques. The following activities are examples of bench-scale research and development projects that are typical of those that may be conducted.

4.2.1 Materials Synthesis and Processing

A fundamental aspect of this research and development effort is the synthesizing and processing of materials. The most common materials employed are polymers and complex oxides. Polymers, such as polyaniline, are used in projects ranging from fuel cell core research to electroluminescent polymers for light emitting diode research. Complex oxides, such as zinc oxide, yttrium oxide, and copper oxide, are used in development of electrochemical sensors and superconductivity devices. The polymers and oxides used are normally in powdered form and are generally non-hazardous.

The most common materials processing technique for complex oxides is radiofrequency (RF) sputtering, which produces thin films of the materials on various substrates. These materials are either further processed into devices or are used in fundamental materials experiments. Another common materials processing technique is polymer synthesis. A powder of a polymer (such as polyaniline) is synthesized, purified, and then formed into a membrane for further study its properties, many of which relate to electronic device development.

Materials processing for fabrication of electronic devices typically includes the use of small hand tools and small amounts of solvents and acids for the preparation of materials. Fume hoods are also used for chemical cleaning and processing.

4.2.2 Material Characterization

Researchers also test materials and devices to determine material properties and characteristics. Specialty equipment, such as scanning electron microscopes (SEM), x-ray diffractometers, and laser spectroscopy are used in these operations. General laboratory space is used for the measurements of sample properties. These material characterization capabilities are often applied broadly across LANL projects.

The SEM facility is used to characterize materials for research and development on electrochemical sensors and on superconductivity, but this facility also has the capability to determine patterns of semiconductor materials. Similarly, the x-ray diffractometer is used to characterize everything from polymer materials to semiconductors.

The existing laser and optics laboratories are used primarily in conjunction with semiconductor and polymer projects. A variety of optical and electro-optic spectroscopy techniques are applied to solid-state samples. Spectroscopic methods used include optical absorption, temporally and spectrally resolved photoluminescence, electroluminescence, Raman spectroscopy, electromodulated absorption, photothermal deflection spectroscopy, and photoconductivity.

4.2.3 Fabrication and Testing of Electronic Devices

These activities take place in small-scale electronic and chemical laboratories. A specific area of research is in polymer electrodes for fuel cell, supercapacitor, and gas sensor applications. These are typically prepared using electrochemical methods. A major effort goes into preparation of membranes for testing fuel cell apparati, where an ongoing activity involves optimization of the catalytic process in direct-methanol fuel cells. Both aqueous and non-aqueous structures for supercapacitors are being developed and tested.

Another device-fabrication facility contains photolithography, ion-milling, metal disposition, and other capabilities for the development of electronic devices. The devices that are processed include polymer light-emitting diode structures, high-temperature superconducting junctions, electrochemical sensors for pollutants such as NOx and SOx, and diamond-crystal and diamond-film-based radiation sensors. This facility also contains material characterization capabilities such as x-ray diffractometry.

Device testing occurs in a number of laboratories for optical testing, microwave testing, and electrical property testing (current-voltage, capacitance voltage, ultra-high speed characterization, etc.). Encapsulated radioactive sources are used as standards for testing radiation detectors. Fuel cell tests are conducted, which requires the use of hydrogen gas for fuel. Electrolysis cells are also tested for recycling of chemicals (such as chlorine gas from anhydrous hydrogen chloride gas.

4.2.4 Electrochemical and Fuel Cell Research

Personnel test metal dissolution, conversion of chemical energy to electricity, or the production of chemicals. A number of different projects are conducted, including development of corrosion cells for screening bipolar plate materials for fuel cells, flow visualization studies for fuel cells, metal removal for decontamination, electrochemical cells for the production of biocides, and other electrochemical testing.

Electrochemical testing involves placing a metal in an electrolyte solution, passing an electric current through the solution, and collecting data. Metals are weighed before and after testing to determine metal losses. Graphite and a variety of metals (such as stainless steel, titanium, aluminum, and platinum) are used, as well as standard laboratory chemicals, (concentrated acids and bases, isopropyl alcohol and other cleaning solvents, and ion exchange chemicals. Compressed air, hydrogen gas, and liquid nitrogen are used.

4.2.5 Support Capabilities

Several facilities, including clean rooms and a small machine shop, are used to support the above research. In all of these areas, small amounts of solvents and acids are used for cleaning. The materials processed include, but are not limited to, polymers, complex oxides, semiconductors, metals, and insulators. A variety of chemicals are used to process these materials, including acids, solvents, carcinogens (such as chloroform), compressed gases (toxic and flammable), liquid gases (liquid nitrogen, etc.), and toxic metals (Ba, Cd, Cr, Pb, Ni, Ag, etc.). These are all used in small, research laboratory quantities. A number of other tools, instruments, and materials are used, including, but not limited to: general laboratory electronic instruments, high voltage power supplies, microwave ion sources, encapsulated radioactive sources, network analyzers, ovens and furnaces, ellipsometers, prolifometers, vacuum systems, ion mill equipment, parylene coaters, deposition chambers, photography equipment, sputter systems, glove boxes, transducers, bench-scale analytical instruments, spectrometers, amplifiers/synthesizers,

spectrum analyzers, hot presses, and UV/VIS sources.

4.3 <u>Advanced Oxidation Technology Research and Development</u>

LANL conducts bench-scale and pilot-scale Advanced Oxidation Technology (AOT) research, which involves the generation and use of highly reactive free radicals, such as O, OH, H, and N, as efficient chemical energy sources for breaking molecular bonds in organic compounds. High-energy electrical power sources are used to create modified ("hot") electrons. The "hot" electrons have very high energy potentials (typically 1-10 electron volts); they collide with other molecules to produce the free radicals. AOTs are non-thermal and require no chemical additives; therefore, large secondary waste streams are not generated.

Advanced Oxidation Technologies can be used for treating a variety of hazardous components, both in aqueous- and gaseous-based effluents. The free radicals involved in AOTs either reduce or oxidize chemicals to simpler, less hazardous, or benign components. AOT research currently employs a technique termed nonthermal plasmas (NTPs). NTP research is ongoing, as well as other similar techniques that are non-thermal, require no chemical additives, and generate highly reactive free radicals. This research is primarily conducted at TA-35.

Nonthermal plasmas (NTPs) can be used for treating stack/flue/off-gases, soil vapor extractions, incinerator off-gases, auto emissions, and wastes generated by a variety of industries. Examples of applications that LANL researchers study include: 1) solvents/chemicals in soil and/or groundwater (such as trichloro-ethylene, trichloroethane, perchloroethylene, methylene chloride, toluene, benzene, ethylene, xylene, chloro-fluorocarbons, etc.); 2) oxides of nitrogen (NOx) from diesel-engine or aircraft-engine exhaust; 3) pyrolyzer exhausts (e.g., styrene); and 4) modifying surface characteristics (such as wetability, repellence, and adhesion) of materials. One type of nonthermal plasma, Silent Discharge Plasma (SDP), consists of two parallel metal electrodes with a dielectric barrier between and adjacent to one or both electrodes. High voltage is applied between the electrodes, creating microdischarges in gases flowing between them.

The electrical energy produces highly reactive free radicals, which can then oxidize, reduce, or directly fragment pollutants. The SDP system is normally operated in open-loop mode and consists of treatment cells, a power supply, a secondary containment tank, scrubbers and filters, and monitoring equipment. SDP cells are less than one meter long and about 0.3 meters wide. Depending on the flow of gases through the system, more or fewer cells would be needed for adequate treatment. Another type of nonthermal plasma, pulsed corona systems, is also employed by LANL researchers to form electrical discharge in gases. Pulsed corona systems are another type of nonthermal plasma and are very similar to SDP.

The Silent Discharge Plasma system is often used with an electrically heated Packed Bed Reactor (PBR) to create a closed-loop/two-step system. The PBR is an electrically heated column of closely packed alumina (ceramic) beads, and is the first step in this system. High voltage heats the alumina beads to localized, very high temperatures. Solutions are introduced into the PBR, where many of the hazardous organic compounds are volatilized and completely decomposed. The off-gas, containing undestroyed components, is then treated in the SDP cells. The treated gas is recycled back through the system until the desired destruction efficiencies have been achieved.

The typical gas flow rates for nonthermal plasma systems range from a few cubic centimeters (cm3) per minute to a few 100 liters/min. The pilot-scale systems’ flow rate is usually several tens of liters/min to several 100 liters/min. The bench-scale systems' flow rate is normally at the low end of the flow regime.

One of LANL's pilot-scale SDP systems is trailer-mounted. This SDP system is used away from TA-35, such as other LANL locations or at locations within the U.S., (other federal facilities). At off-site locations, LANL personnel obtain all necessary permits and permission, such as Resource Conservation and Recovery Act (RCRA) permits and written formal agreements. All local, state, and federal laws and regulations are followed when conducting these off-site experiments.

Personnel use a variety of chemicals to test the destruction efficiencies of these techniques. These include RCRA- or Toxic Substances Control Act (TSCA)-listed compounds (such as trichloroethylene, perchloroethylene, carbon tetrachloride, benzene, toluene, xylene, polychlorinated biphenyls, ammonia, sulfur hexafluoride, and sulfur and nitrogen oxides); high vapor pressure metals; hydrocarbon-based fuels (such as iso-octane, kerosene, diesel, jet fuel, and propane); oxygen; carbon dioxide; nitrogen; water; and other similar materials. The diverse chemicals are used to simulate different waste streams. For bench-scale projects, researchers use a few cm3 to several cm3 per experimental run. For pilot-scale projects, researchers use several cm3 to hundreds of cm3 of chemical per experimental run.

Any experiments involving actual hazardous waste are permitted according to New Mexico Environment Department (NMED) rules and regulations pertaining to RCRA, TSCA, and any other pertinent laws. Treatability studies are conducted to determine the suitability and effectiveness of nonthermal plasma techniques.

Personnel follow hazard control plans when conducting this work. They wear personal protective equipment, such as safety glasses and gloves, and conduct hazardous chemical work in certified chemical fume hoods. Engineering controls, such as physical enclosures, shut-off valves, venting, and back-up filtration, are installed prior to beginning work. Waste is disposed of according to facility procedures.

4.4 High-Temperature/High-Pressure Fluids Research and Development

LANL conducts research and development projects designed to develop, test, and verify high-temperature/high-pressure fluid technologies. These technologies include hydrothermal processing, "supercritical" water oxidation, "supercritical" carbon dioxide, and other similar technologies. When certain fluids are driven to high temperatures and pressures, in the “supercritical” region, they may be used as a gas and as a liquid. These supercritical fluids are particularly useful as solvents. Gases, most organic molecules, and some inorganic salts are completely soluble in these supercritical fluids, and the fluids can be used for a variety of purposes, as described below.

Personnel conduct basic research on the physical properties of fluids and other materials, reaction kinetics and process parameters, oxidation and reduction chemistry, and other related chemical reactions. They apply these technologies to a variety of different uses, including precision cleaning, extraction of contaminants and residual solvents, chemical synthesis, polymer synthesis, chemical waste destruction (such as hazardous, mixed, or high explosives waste), semiconductor processing, chemical separations, materials modification, and other related applications.

Experiments are conducted in a number of facilities across LANL and involve both bench-scale and pilot-scale studies. Bench-scale experiments typically involve flow rates of milliliter to liter quantities per hour. Small pilot-scale studies involve flow rates of about 10 liters per hour, and large pilot-scale studies would involve flow rates of several hundred gallons per day. The larger studies involve primarily water containing small quantities of materials of interest. These are typically treatability studies and are operated on a less-frequent basis.

The equipment used for this research generally consists of the pumping and flow system, high-pressure generation equipment and instrumentation, preheaters, reaction vessels or cleaning and extraction vessels, effluent separation equipment (for separating gaseous from liquid effluent), cooling vessels, effluent holding tanks, and various computer control modules. Various analytical chemistry techniques and diagnostic tools are used for chemical species identification, measuring fluid properties, and evaluating other analytical chemistry parameters. The reaction or cleaning and extraction vessels vary in capacity from less than one liter, to hundreds of liters, and either operate as a continuous flow or in a batch mode. All high-pressure equipment, such as pressure-relief valves and reaction vessels, are rated in accordance with ASME Boiler and Pressure Vessel Code, Section VIII rules, and operated within facilities fully equipped for such research.

The majority of the materials used for these experiments include water, carbon dioxide, or other gases such as ethane, propane, butane, dimethyl ether, and fluoroform. Typical small pilot-scale experiments involve a solution containing 60-80% water. Other materials are used in smaller quantitiesm and include acids (such as nitric, hydrochloric, and sulfuric), bases (such as potassium hydroxide and sodium hydroxide), inorganic salts (such as sodium salts and potassium salts), organic salts (such as sodium EDTA, oxalates, formates, and acetates), solvents (such as methanol, isopropanol, and acetone), carcinogens or suspect carcinogens (such as benzene, chloroform, and methylene chloride), explosives, metals (chromium, iron, calcium, nickel, zinc, copper, palladium, etc.), radionuclides (such as depleted uranium), oxidizers (such as hydrogen peroxide), and other similar materials. These experiments do not involve any radionuclides classified as special nuclear materials. Some materials, such as carbon dioxide or other gases, may be recycled through the system and reused.

Pilot studies using actual hazardous or mixed waste may be conducted to demonstrate the suitability of high-temperature/high-pressure technologies for treatment of specific waste streams. These studies determine the effectiveness of supercritical fluid technology as a waste stream treatment technology. Research is designed to determine any pretreatment needs, optimal conditions for the process, material compatibility, and the potential hazards associated with the process. Pilot-scale treatability studies are conducted according to specific requirements established by the New Mexico Environment Department.

Personnel follow hazard control plans when using high-pressure equipment, toxic and hazardous chemicals, radionuclides, and other hazardous materials and equipment. They wear all necessary personal protective equipment, such as goggles or face shields, gloves, etc. If required, personnel perform chemical work within fume hoods. Experiments involving radionuclides (such as experiments with surrogate mixed waste) are conducted with appropriate shielding, such as gloveboxes. If necessary, minor facility modifications such as air filtration systems and monitors, radiation and blast shielding, and other engineering controls are added to existing facilities to protect personnel from radioactive, high-pressure, and other hazards. Work with hazardous or explosive materials are conducted at an appropriate LANL facility.