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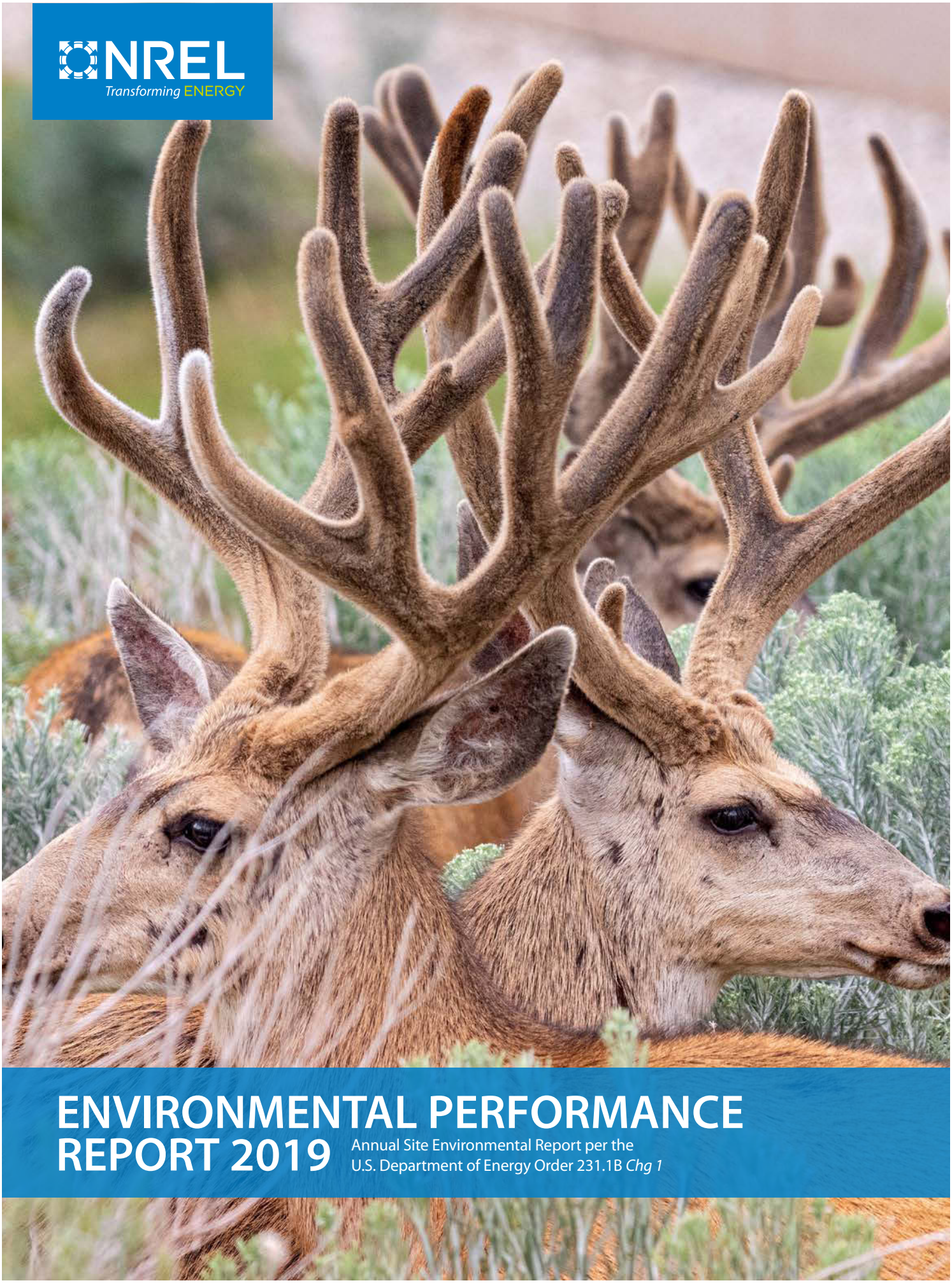

ENVIRONMENTAL PERFORMANCE REPORT 2019

Annual Site Environmental Report per the U.S. Department of Energy Order 231.1B *Chg 1*

Cover Photo: A small herd of Mule deer (*Odocoileus hemionus*) bucks roaming the South Table Mountain (STM) Campus of the National Renewable Energy Laboratory (NREL). Photo by Werner Slocum, NREL 58285.

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Brenna Birt
Rachael Boothe
Genevieve Braus
Theodore DeVito
Larry Durbin
John Eickhoff
Eryn Lussier
Tom Ryon
Kurt Schlomberg
Eric Schmitz

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CONTACT US

We welcome your feedback and suggestions on this report and on NREL's efforts toward sustainability and environmental stewardship. To provide comments, request a printed copy of this report, or obtain additional information about NREL's environmental programs, contact any of the NREL staff members listed below:

Henry Higaki
Director, Environment, Safety, Health, and Quality Office
henry.higaki@nrel.gov
303-275-4212

John Eickhoff
Environmental Manager
john.eickhoff@nrel.gov
303-275-3217

Rachael Boothe
Environmental Specialist
rachael.boothe@nrel.gov
303-275-4004

Leigh Ramsey
Communications Office
leigh.ramsey@nrel.gov
303-275-3668

This report is available online at www.nrel.gov/about/ehs.html

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
303-275-3000
www.nrel.gov

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Photo by Werner Slocum, NREL 61046

NOMENCLATURE

APCD	Air Pollution Control Division
APEN	air pollutant emission notice
APHIS	Animal and Plant Health Inspection Service
AST	aboveground storage tank
CFC	chlorofluorocarbon
CIP	controlled import permit
CCR	Colorado Code of Regulations
CDLE	Colorado Department of Labor and Employment
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
CGI	controllable grid interface
cm	centimeter
CO_2e	carbon dioxide equivalent greenhouse gas emissions
CoMET	Composites Manufacturing Education and Technology
CRS	Colorado Revised Statute
CWA	Clean Water Act
DERTF	Distributed Energy Resources Test Facility
DFD	Denver Fire Department
DOE	U.S. Department of Energy
DOPS	Division of Oil and Public Safety
DWR	Division of Water Resources
EA	Environmental Assessment
EMS	Environmental Management System
EO	executive order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronic Product Environmental Assessment Tool
ESA	Endangered Species Act
ESH&Q	Environment, Safety, Healthy, & Quality Office
ESIF	Energy Systems Integration Facility
FTLB	Field Test Laboratory Building
FY	fiscal year
GHG	greenhouse gas
HAP	hazardous air pollutants
HFC	hydrofluorocarbon
HFO	hydrofluoroolefin
HMWMD	Hazardous Materials and Waste Management Division
IBRF	Integrated Biorefinery Facility
ISO	International Organization for Standardization
JSF	Joyce Street Facility

kg	kilograms
L	liters
MBTA	Migratory Bird Treaty Act
mCi	millicurie
MCL	maximum contaminant level
mg/L	milligrams per liter
mrem	millirem
MS4	Municipal Separate Storm Sewer System
MT	metric ton
NEPA	National Environmental Policy Act
NOx	nitrogen oxides
NPS	National Park Service
NREL	National Renewable Energy Laboratory
NWTC	National Wind Technology Center
ODS	ozone-depleting substances
ORC	operator in responsible charge
OTF	Outdoor Test Facility
PDU	process development unit
PFAS	Per- and Polyfluoroalkyl Substances
PUE	power usage effectiveness
ReFUEL	Renewable Fuels and Lubricants Research Laboratory
RFHP	Renewable Fuel Heat Plant
RSF	Research Support Facility
S&TF	Science & Technology Facility
SERF	Solar Energy Research Facility
SPCC	spill prevention control and countermeasures
SRRL	Solar Radiation Research Laboratory
STL	Structural Testing Laboratory
STM	South Table Mountain
TTB	Alcohol and Tobacco Tax and Trade Bureau
TTF	Thermal Test Facility
TTHM	total trihalomethanesUSACE U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compounds
VTIF	Vehicle Testing and Integration Facility
WHF	Waste Handling Facility
WMFR	West Metro Fire Rescue
WQCD	Water Quality Control Division
yr	year

A Common Grackle (*Quiscalus quiscula*) perches in a tree near the parking garage at the South Table Mountain Campus. They are just one of several species of birds that make NREL their home. *Photo by Werner Slocum, NREL 56765*

EXECUTIVE SUMMARY

Purpose

The National Renewable Energy Laboratory's (NREL's) Environmental Performance Report describes the laboratory's environmental management activities in 2019. It includes information on environmental and sustainability performance; environmental compliance activities and status; and environmental protection programs, highlights, and successes.

The purpose of the report is to ensure the U.S. Department of Energy (DOE) and the public receive timely, accurate information about events that have positively affected or could adversely affect the health and safety of the public or workers, the environment, or the operations of DOE facilities. The report meets the DOE requirements of the Annual Site Environmental Report and has been prepared in accordance with DOE Order 231.1B *Chg 1, Environment, Safety and Health Reporting*.

Environmental and Sustainability Performance

NREL is committed to environmental stewardship, pollution prevention, compliance with environmental requirements, and continual improvement in environmental protection and sustainability performance. The laboratory's Environmental Management System (EMS) implements a framework of policies, procedures, and programs that integrates environmental protection into daily work practices. The EMS is structured based on a plan-do-check-act continual improvement management model, and it is implemented as part of an Integrated Safety Management System.

Each year, the laboratory sets measurable goals for environmental improvement through the EMS planning process. Goals are also established through the Performance Evaluation and Measurement Plan and the Site Sustainability Plan. Progress for all goals is tracked throughout the year using an online software tracking system. A summary is prepared annually for the DOE Golden Field Office on Performance Evaluation and Measurement Plan results and for DOE Headquarters On-Site Sustainability Plan results. The laboratory

identified several goals in 2019 to enhance sustainability and environmental performance and made—and continues to make—significant progress toward them.

Sustainability is integral to both NREL's research and operations, and the laboratory is committed to demonstrating federal leadership in sustainability. NREL operates as a living laboratory by implementing strategies and technologies in its facilities and then studying the adoption and effectiveness through participation by staff.

The following are some of the laboratory's key accomplishments in 2019:

- Maintained International Organization for Standardization 14001:2015 certification for environmental management systems, as verified by a team of external auditors.
- Developed online National Environmental Policy Act (NEPA) training for staff that support NEPA evaluations, and a NEPA General Awareness training for all interested staff. The trainings are designed to improve awareness of and compliance with the laboratory's NEPA process.
- Observed a common muskrat (*Ondatra zibethicus*) at the South Table Mountain (STM) Campus.
- Began development on several of the Municipal Separate Storm Sewer System permit program areas to reduce the discharge of pollutants in stormwater runoff from the STM Campus.
- Provided training sessions to NREL staff on snake ecology and taxonomy to minimize injuries to snakes and to enhance safety awareness of responders during snake relocation activities. The training was conducted by a local consulting firm specializing in human-wildlife interactions.
- Observed Tree Swallows (*Tachycineta bicolor*) and American Kestrels (*Falco sparvierus*) that returned to nest boxes and successfully fledged young at the STM Campus.
- Installed water meters in two buildings at the Flatirons Campus for the purpose of designing and permitting a new on-site wastewater treatment system, and to help identify water-saving opportunities.
- Reviewed tree and shrub types for the Flatirons Campus Landscape Project, which included assessing plants for wildlife and pollinator habitat, wildfire risk, and maintenance requirements.
- Conducted a wetland delineation of the middle drainage area within the STM Campus. Based on a field investigation, approximately 1.70 acres (0.69 hectares) of nonjurisdictional wetlands were identified within the study area. This information will be submitted to the U.S. Army Corps of Engineers in 2020 for a jurisdictional determination and will be used for future planning purposes for development within the STM Campus.

NREL's Continued International Organization for Standardization (ISO) 14001 Certification Demonstrates Commitment to Environmental Leadership

NREL's Environmental Management System has been ISO 14001-certified since 2011, and the laboratory maintained this certification in 2019. A team of external auditors conducted an independent assessment of the policies, procedures, tools, and roles and responsibilities used in environmental management at NREL. The assessment verified that the laboratory continues to meet the requirements of ISO 14001, which demonstrates the laboratory's commitment to environmental stewardship.

Prestigious Environmental Sustainability Awards and Recognition Received

NREL received the following important recognitions in 2019 for its environmental and sustainability accomplishments:

- Four-star Electronic Product Environmental Assessment Tool (EPEAT) purchases award from the Green Electronics Council for excellence in the procurement of sustainable electronics
- DOE GreenBuy Superior Award for demonstrating leadership and continuous improvement in transitioning to more sustainable products
- Colorado Environmental Leadership Program Gold-Level Leader status for exceeding regulatory requirements and for continued partnership with the Colorado Department of Public Health and Environment since 2004.

- Maintained professional relationships with various departments within Jefferson County and the Colorado Division of Parks and Wildlife. As a result, NREL received a notification from the Jefferson County Noxious Weed Coordinator that a small patch of leafy spurge was discovered by a hiker on the DOE STM conservation easement property. Additionally, Jefferson County Open Space provided the location of a previously unknown myrtle spurge (*Euphorbia myrsinites*) patch on the STM Campus; the areas were treated and will be surveyed again in 2020.
- Assessed NREL's cybersecurity systems for the protection of distributed energy resources. This included evaluating management system controls associated with multiple renewable energy sources and control systems that are independent of the STM Campus central plant.

- Participated in regional working groups and provided technical expertise to state and federal groups to further their resilience planning. These groups included the Colorado Resiliency Institutionalization Project, the State of Colorado Resilience Working Group, the Federal Emergency Management Program, and the Department of Homeland Security.
- Implemented erosion and sediment control plans for several small construction projects (projects that disturb less than one acre [0.4 hectare]) at the STM Campus, which helped prevent sediment deposits to nearby surface drainages and downstream waters.
- Conducted Chemical Response Team operational drills and joint exercises internally and with external response organizations. The exercises were designed to train and strengthen response capabilities for potential incidents involving hazardous materials.
- Developed a Wildlife Response Operational Plan that explains roles, responsibilities, and appropriate responses for a variety of wildlife-related calls.
- Observed a Bullock's Oriole (*Icterus bullockii*) at the STM Campus.

Environmental Compliance and Monitoring

NREL is subject to many federal, state, and local environmental laws and regulations, in addition to executive orders, DOE requirements, and agreements with government agencies.

The laboratory continued its excellent record of environmental compliance in 2019. No violation notices were received from any regulatory agency and all required permits were received or renewed, required registrations were completed, and required notifications and reports were submitted.

Unlike many other DOE facilities, NREL does not conduct work involving nuclear materials and does not have legacy radiological or other contamination issues associated with past nuclear weapons production or research activities; therefore, continuous radiation or radiological contamination monitoring is not conducted.

NREL collaborates with many federal, state, and local governments. Here, staff for the U.S. House Committee on Appropriations—Energy and Water Development Subcommittee get a view of the Flatirons Campus from the top of a test turbine alongside NREL employees. *Photo by Dennis Schroeder, NREL 59187*

Environmental Management Programs

The laboratory continued to improve its environmental management and performance in 2019, as demonstrated by a track record of excellent compliance with regulatory requirements and established leadership in environmental and sustainability management. Major environmental programs include:

- Air quality protection, including air permitting, ozone-depleting substance management, and greenhouse gas emissions monitoring
- Water quality protection, including construction stormwater management, drinking water monitoring, and prevention of unallowable sanitary sewer system discharges
- Hazardous materials and waste management, including pollution prevention; spill response; proper storage, use, and disposal of hazardous chemicals and materials; planning, permitting, and reporting the use and emissions of materials
- National Environmental Policy Act reviews
- Natural and cultural resources protection, including wildlife, vegetation, protected species, wetlands, and cultural resources management.

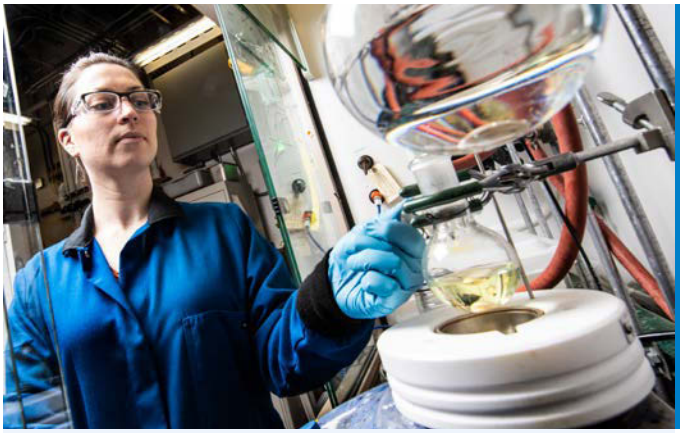
ABOUT NREL

NREL is the principal research laboratory for DOE's Office of Energy Efficiency and Renewable Energy. The laboratory also conducts research for the Office of Science and the Office of Electricity Delivery and Energy Reliability. The Alliance for Sustainable Energy, LLC, a partnership of MRIGlobal and the Battelle Memorial Institute, manages the laboratory for the Office of Energy Efficiency and Renewable Energy.

NREL is the only DOE national laboratory solely dedicated to advancing renewable energy and energy efficiency technologies from concept to commercial application. The laboratory's innovations, analysis, and expertise have helped enable the emergence of a U.S. clean energy industry and have led to numerous success stories across the laboratory. NREL's two campuses—the 327-acre (132 hectares) STM Campus in Golden, Colorado, and the 305-acre (124 hectares) Flatirons Campus in northern Jefferson County—are living models of sustainable energy integration.

NREL develops renewable energy and energy efficiency technologies and practices, advances related science and engineering, and transfers knowledge and innovations to address the nation's energy and environmental goals. The laboratory's research and development achievements have helped shape clean-energy alternatives for powering our homes and businesses, and the nation's transportation infrastructure. NREL's science and technology teams span the full spectrum of innovation, from fundamental science and market-relevant research, to systems integration and testing and validation.

Garden yellowrocket (*Barbarea vulgaris*) or Wintercress at the Flatirons Campus. *Photo by Bob Fiehweg, NREL 24473*



An NREL researcher sets up a reaction to make new electrolyte materials for all-solid-state batteries in the Nanoscale Systems Fabrication Laboratory at the Solar Energy Research Facility (SERF) on the South Table Mountain (STM) Campus. *Photo by Dennis Schroeder, NREL 61180*

1 INTRODUCTION

This report summarizes the National Renewable Energy Laboratory's (NREL's) environmental management activities in 2019, including:

- Environmental protection programs
- Environmental and sustainability performance
- Environmental compliance activities and their status
- Environmental management highlights and successes.

The report incorporates the U.S. Department of Energy (DOE's) most recent guidelines for the Annual Site Environmental Report, as required by DOE Order 231.1B *Chg. 1, Environment Safety and Health Reporting*.

1.1 Our Mission

NREL's mission focuses on advancing the energy goals of DOE and our nation. This focus is captured in the following mission statement:

> NREL advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies, and provides the knowledge to integrate and optimize energy systems.

NREL fulfills its mission through technology portfolios. A brief description of each major technology area follows.

- **Advanced Manufacturing:** Scientific and engineering research at NREL focuses on reducing energy requirements associated with the most energy-intensive manufacturing industries and accelerating those innovations to commercialization of next-generation technologies and processes.
- **Bioenergy:** NREL bioenergy investigations advance technologies to produce biobased fuels, products, and energy. Research ranges from discovery science to pilot-scale processing related to biochemical conversion, thermochemical conversion, and life-cycle analyses.

An NREL research technician works on finding ways for a commercial building to store energy to offset costs during peak hours, using both thermal and battery power at the Energy Systems Integration Facility (ESIF) at the STM Campus. *Photo by Werner Slocum, NREL 60946*

- **Building Efficiency:** NREL supports the research and development of technologies and practices for building energy efficiency, working closely with industry and manufacturers. NREL also promotes energy- and money-saving opportunities to builders and consumers, and works with state and local regulatory groups to improve building codes and appliance standards.
- **Chemistry and Nanoscience:** NREL investigates materials and processes for converting renewable and clean energy resources into chemical and electrical energy. Resources, such as sunlight, heat, and renewable materials, are converted to fuels and other chemical and electrical energy-storage modes. Staff conduct research across the entire spectrum—from performing foundational science to working closely with industry to commercialize new technologies.
- **Computational Sciences:** The laboratory works to solve energy challenges using high-performance computing; computational science; applied mathematics; and scientific data management, visualization; and informatics. Also, NREL is home to the world's largest high-performance and most energy-efficient data center dedicated to advancing renewable energy and energy efficiency technologies.
- **Concentrating Solar Power:** NREL staff provide scientific, engineering, and analytical expertise to help advance innovation in concentrating solar power technologies. Concentrating solar power is unique in its ability to store thermal energy in inexpensive and efficient thermal energy storage systems.
- **Energy Analysis:** NREL's energy analysis informs policy and investment decisions that lead to more resilient, reliable, and efficient energy systems. With objective, technology-neutral analysis, NREL aims to increase understanding of energy policies, markets, resources, technologies, and infrastructure to address economic, security, and environmental priorities.
- **Energy Systems Integration and Grid Modernization:** NREL staff at both the Energy Systems Integration Facility on NREL's South Table Mountain Campus and at the National Wind Technology Center on NREL's Flatirons Campus collaborate with industry and academic partners to test the ability of the electric grid to incorporate sources of renewable energy and investigate ways to modernize the electric grid infrastructure to improve its reliability, resiliency, and security.
- **Geothermal Energy:** Geothermal energy research at NREL includes developing new techniques to increase the production of geothermal energy; exploring the benefits of combining geothermal and other renewable energy systems; and collaborating with industry, government agencies, and other partnering entities to advance the use of geothermal energy worldwide.
- **Hydrogen and Fuel Cells:** The laboratory's hydrogen and fuel cell research and development program focuses

An NREL researcher works with samples of algae in the Biofuels Research Laboratory at the Field Test Laboratory Building (FTLB) at the STM Campus. *Photo by Dennis Schroeder, NREL 60866*

on developing, integrating, and demonstrating hydrogen production and delivery, hydrogen storage, and fuel cell technologies for transportation, stationary, and portable applications.

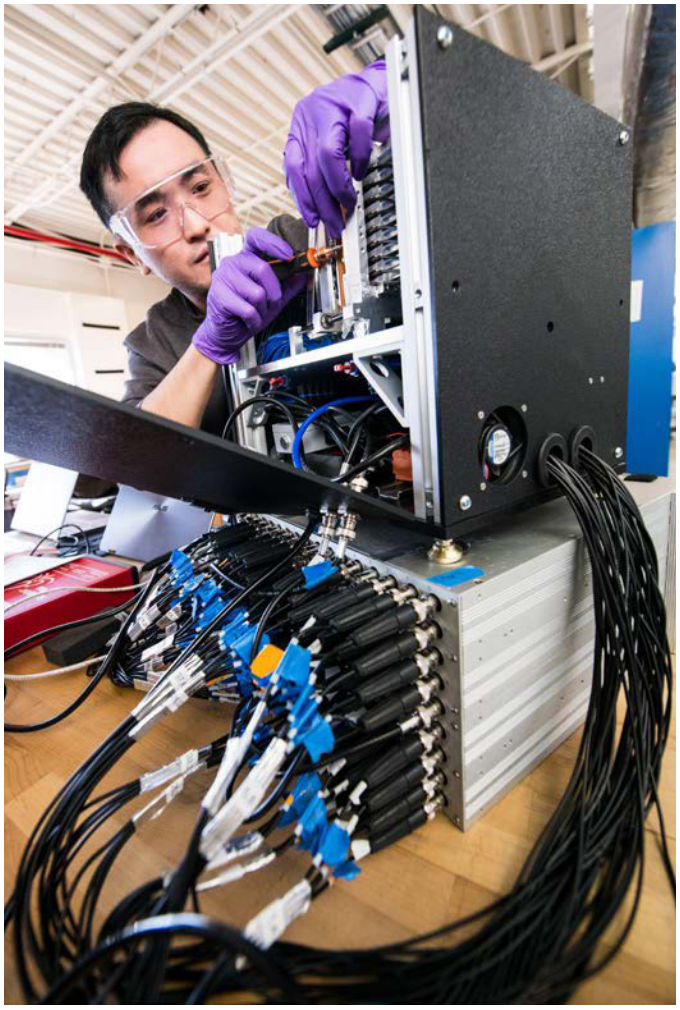
- **Integrated Energy Solutions:** NREL supports the transition to renewable energy portfolios at the city, state, national, and international levels by performing technical and economic evaluations of renewable energy opportunities that address technology, policy, social, and market systems.
- **Materials Science:** NREL provides fundamental and applied materials science discovery and problem-solving for current and next-generation renewable energy and energy-efficient technologies. Focus areas include materials physics, electronic structure theory, analytical microscopy and imaging science, interfacial and surface science, materials discovery, and thin-film material science and processing for photovoltaics and other energy applications.
- **Photovoltaics and Solar Power:** NREL's capabilities in photovoltaics include both fundamental and applied research and development, such as theory and modeling, materials deposition, device design, measurements and characterization, and reliability testing and engineering.
- **Transportation:** NREL collaborates with industry experts to develop advanced vehicles and transportation systems. NREL also works with energy companies and manufacturers of vehicles and engines to develop advanced motor vehicle fuels for improved energy and environmental performance.
- **Water Power:** NREL's water power program focuses on advancing the use of hydropower through data validation, development of innovative water power technologies, and the use of toolkits to assist water power sector businesses in navigating hydropower regulations.
- **Wind Energy:** From conceptualizing taller turbines capable of greater energy capture to assessing U.S. offshore wind energy needs and potential, the National Wind Technology Center drives wind industry acceleration. Facilities at the Flatirons Campus also enable testing of turbine-drivetrain components; designing, researching and validating advanced wind power plant control systems; and manufacturing and testing turbine blades of various new composite materials.

NREL researchers work in the Power Systems Integration Laboratory in the Energy Systems Integration Facility (ESIF) at the STM Campus. *Photo by Dennis Schroeder, NREL 61502*

1.2 Site and Facility Description

NREL's five facilities occupy four separate locations in Jefferson County and one location in the City and County of Denver. These include:

- South Table Mountain (STM) Campus
- Flatirons Campus
- Denver West Office Park
- Golden Warehouse
- Renewable Fuels and Lubricants Research Laboratory



A hardware engineer works in the Thermal Test Facility (TTF) on the STM Campus setting up a new prototype to help decrease the cost of electric vehicles and storage batteries. *Photo by Dennis Schroeder, NREL 60786*

The STM Campus and the Flatirons Campus are the primary locations for NREL research operations. Leased space in the Denver West Office Park is used for administrative and research activities. The leased Golden Warehouse is used to store equipment. The Renewable Fuels and Lubricants Research Laboratory facility is a leased research space that consists of a single-vehicle high bay and a small office area housed within the Regional Transportation District's District Shops and Operations Center facility in Denver.

Climate

The climate of the geographic region of NREL operations is classified as semiarid and is typified by limited precipitation, low relative humidity, abundant sunshine, and large daily and seasonal temperature variations.

The area experiences an average annual rainfall of less than 20 inches (50 centimeters [cm]). Almost half the annual precipitation occurs from March to June. Summer showers contribute 33% of the annual precipitation total. Precipitation begins to decrease significantly in the fall and reaches the minimum during winter. Winter is the driest season, contributing less than 10% of the annual precipitation, primarily in the form of snowfall.

Spring is a season of unstable air masses with strong winds along the foothills of the Front Range. The highest average monthly snowfall typically occurs in March, when at least one snowstorm of 6–10 inches (15–25 cm) often occurs.

The solar radiation (sunlight energy) of the region is excellent for conducting research outside and testing solar energy conversion devices and systems. Sunshine is abundant throughout the year and remarkably consistent from month to month and season to season.

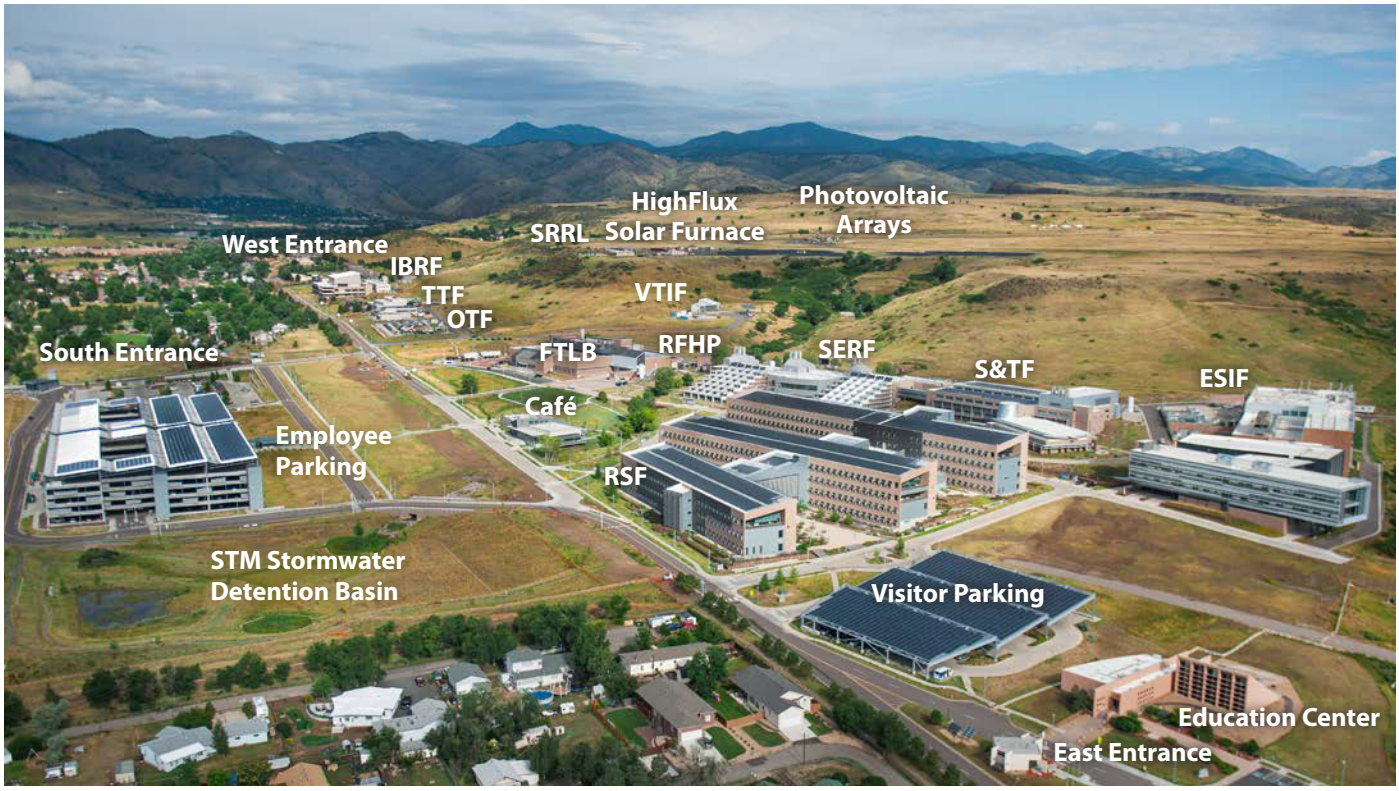
South Table Mountain Campus

The STM Campus is the main research center for NREL—nearly 80% of the laboratory's staff has offices and laboratories there. The STM Campus is approximately two miles (3.2 kilometers [km]) east of Golden and 12 miles (19.3 km) west of central Denver.

Land Use

The STM Campus is a roughly triangular parcel of land occupying portions of the top and lower south-facing slopes of South Table Mountain, a mesa that stands 492 feet (150 meters [m]) above the adjacent lowlands. South Table Mountain is composed of sedimentary rocks below a basalt lava cap that is quite resistant to erosion.

The STM Campus is a 327-acre (132-hectare) area bordered predominantly by open grassland zoned for recreation and light commercial activity. Portions of the community of



NREL's South Table Mountain (STM) Campus. *Photo by Dennis Schroeder, NREL 30709*

Pleasant View are located immediately to the south and west. Pleasant View has constructed a recreational park immediately south of the STM Campus; offices, shops, and a tree nursery owned by the Colorado State Forest Service are located at the far western edge of the STM Campus. Undeveloped state land and a Colorado State Highway Patrol pursuit driver-training track are located along the northwestern boundary of the STM Campus on top of the mesa. Jefferson County Open Space wraps around the northern and eastern edges of the site. Portions of the Denver West Office Park and apartment homes lie to the east.

More than half of the STM Campus (177 acres [72 hectares]) is preserved in a conservation easement. No development is allowed on that land, with the exception of some existing utility easements and recreational trails to be established by Jefferson County Open Space. For details, see Section 10, Conservation Lands.

Geology, Soils, and Hydrogeology

South Table Mountain was formed as weak sedimentary rocks surrounding lava were eroded away, leaving the lava-capped mesa in relief. The sedimentary rocks beneath the lava caprock are part of the Denver Formation, which consists of layers and lenses of claystone, sandstone, and conglomerate. Sedimentary rocks of the Arapahoe Formation underlie the Denver Formation.

The Arapahoe, Laramie-Fox Hills, and Denver Formations are considered to be aquifers in portions of the Denver Basin. The Denver Formation underlies the areas on which most NREL construction has taken place. Groundwater on the STM Campus is found primarily in the weathered and fractured silts and sands of the Denver Formation. Some groundwater, in the form of perched aquifers, may also be below the basaltic lava cap on South Table Mountain and within the materials above the Denver Formation, which are largely the result of stream deposits. Groundwater flow on the site is in a southeasterly direction.

The soil covering the top of South Table Mountain is lavina loam. Loam is composed of a mixture of clay, sand, silt, and organic matter. The loam on the mesa top is a shallow, well-drained clayey soil. Soil on the upper side slopes of South Table Mountain is also loam and consists of extremely stony soils with significant amounts of clay. Much of the remainder of the site, including the area designated for major development, has a deep well-drained soil referred to as Denver clay loam that consists of clayey material containing some calcium carbonate. There are also two smaller soil areas on the southwestern portion of the site, both of similar character to other site soils—cobbly clay loam and very stony clay loam.

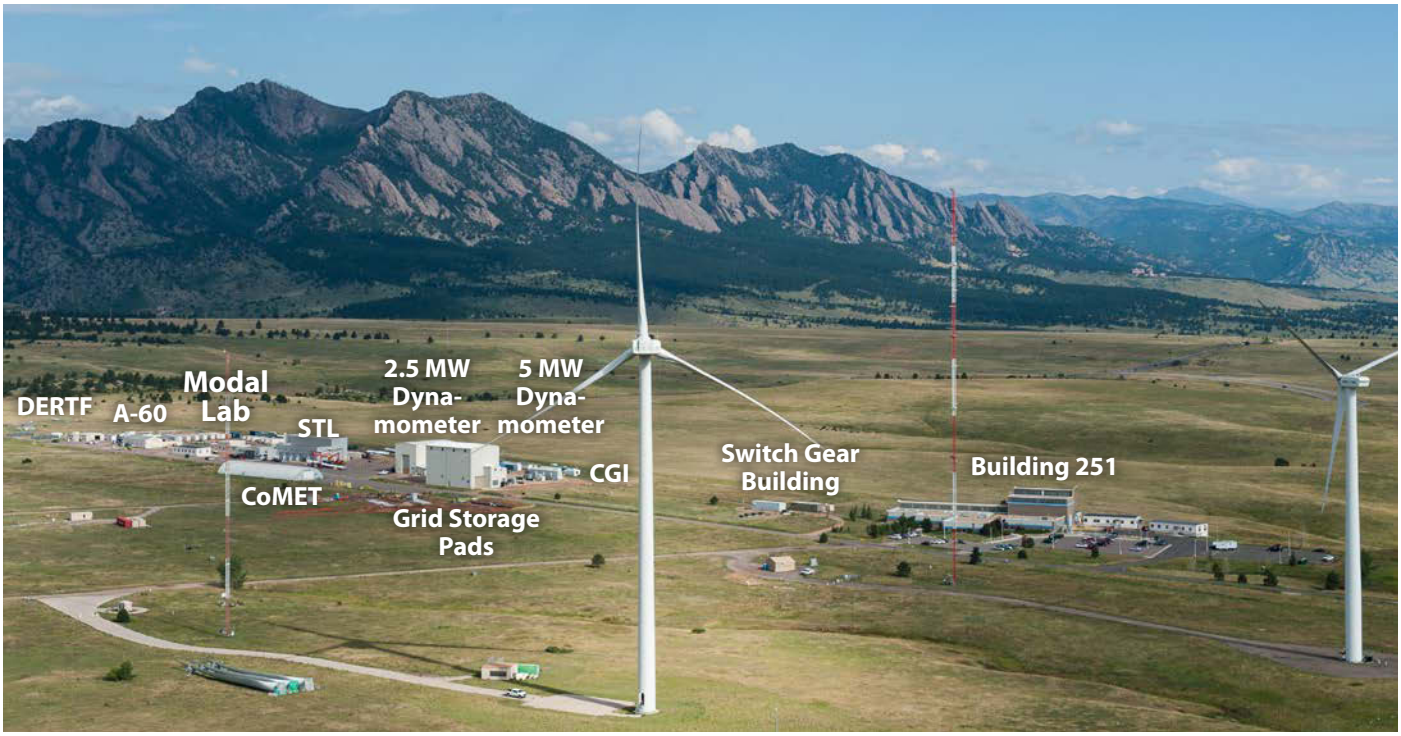
Surface Water

About 90% of the surface drainage from the site, both from the mesa top and across the lower portions of the site, flows in a southeasterly direction toward Lena Gulch (a tributary of Clear Creek). Though there is no permanent stream flow on the STM Campus, occasional flow from extended periods of precipitation, usually during the late winter and early spring, is found in the drainage channels, with seasonal springs being evident along some of the mesa top slopes. The mesa top features one seep that is often active throughout much of the year; however, the water that reaches the surface infiltrates and evaporates quickly during the dry season.

Vegetation

Two primary vegetation types are present on the STM Campus: grasslands and shrublands. The most common plant communities on the STM Campus are mixed grasslands; they comprise more than 80% of the vegetation on the site. These communities are generally dominated by short- and mid-grass species. Two primary upland shrub communities are found on the STM Campus: mountain mahogany shrublands are found on the shallow soils of the mesa, and upland shrublands appear in both drainages lacking active channels and drainages with associated wetlands. Field surveys have identified limited wetland and riparian areas along drainages. The wetland communities identified on the STM Campus are a minor component of the total vegetation cover, accounting for less than 1% of the vegetation over an area of less than 0.75 acre (0.3 hectare). Riparian shrub communities are also found adjacent to the emergent wetlands. For details, see Appendix D, Plant Communities at the STM Campus and the Flatirons Campus.

NREL researchers test the power take-off system on a dynamometer designed for wave energy conversion at NREL's Flatirons Campus.
Photo by Dennis Schroeder, NREL 59097



NREL's Flatirons Campus. *Photo by Dennis Schroeder, NREL 30766*

Wildlife

Since 1987, several comprehensive wildlife surveys have been conducted on the STM Campus. Numerous mammals, and several types of amphibians and reptiles, have been identified during the surveys. More than 75 species of birds and several raptor species have also been recorded at or above the STM Campus through formal wildlife surveys or employee observations. For details, see Section 9.1, Wildlife Management, and Appendix C, Wildlife Species Observed at the STM Campus and the Flatiron Campus.

Flatirons Campus

The Flatirons Campus (formally known as the National Wind Technology Center, or NWTC) is the main facility for NREL's wind turbine technology, water power, and grid integration research. Located on the Jefferson County-Boulder County border just east of the foothills of the Front Range, the Flatirons Campus has abundant wind resources that are critical for the variety of projects conducted at the site. The Flatirons Campus is located near the intersection of Colorado Highway 93 and Colorado Highway 128, between Boulder and Golden, and is approximately 15 miles (24.2 km) north of the STM Campus.

Land Use

The Flatirons Campus occupies 305 acres (124 hectares) that are surrounded by open space, grazing, and industrial land uses. The Rocky Flats National Wildlife Refuge borders the Flatirons Campus to the south and east. A restored sand and gravel mine is located due south (on the refuge's property), and an expanded shale and clay lightweight aggregate production operation is located along the southern portion of the western boundary of the Flatirons Campus. A propellant fracturing company also has a small installation along the northern portion of the western site boundary. The City of Boulder owns open space bordering the Flatirons Campus to the north; State Highway 128 lies north of that open space.

Geology, Soils, and Hydrogeology

The Flatirons Campus is located on a plain formed by stream deposits. The uppermost geological stratum beneath the site is known as the Rocky Flats Alluvium. It is composed of cobbles, coarse gravel, sand, and gravelly clay. Below the Rocky Flats Alluvium are the Laramie Formation, Fox Hills Sandstone, and Pierre Shale. These formations consist primarily of claystones with some siltstones. Unconfined groundwater flow occurs in the Rocky Flats Alluvium toward the east/southeast, and small perched zones are common. Groundwater occurs as confined aquifers in the deeper bedrock formations.[1]

The Flatirons Campus has a strongly developed soil defined as a very cobbly, sandy loam. The soil is characterized by a large amount of cobble and gravel in the soil volume, and by subsoil dominated by clay.

1. EG&G Rocky Flats, Inc. 1992. *Rocky Flats Plant Site Environmental Report: January through December 1992*. Golden, Colorado.

Surface Water

The area surrounding the Flatirons Campus is drained by five streams: Rock Creek, North Walnut Creek, South Walnut Creek, Woman Creek, and Coal Creek. Rock Creek flows eastward and is located southeast of the Flatirons Campus. North Walnut Creek and South Walnut Creek flow eastward into the Great Western Reservoir. Woman Creek drains eastward into Standley Lake. Coal Creek flows in a northeasterly direction across the City of Boulder Open Space north of the Flatirons Campus.

Most of the Flatirons Campus drains into a tributary to Rock Creek. Some of the northern portions of the site drain into Coal Creek or its tributaries.

Vegetation

The Flatirons Campus is located in the transition area between the Great Plains and the Rocky Mountains.[2] This location results in a flora that contains elements of both mountain and prairie ecosystems, as well as associations that represent residual tallgrass prairie, short-grass plains, ponderosa pine woodland, and foothill ravine flora.[3]

Vegetation surveys conducted on the Flatirons Campus have identified more than 270 vascular plant species and defined five major habitat types, including xeric-mixed grasslands, pine woodlands, shrublands, wetlands, and disturbed areas.

Along a northwestern ridge of the Flatirons Campus is a ponderosa pine woodland area. Vegetation found in this area includes woody species with an understory of grasses, forbs, and shrubs. For details, see Appendix D, Plant Communities at the STM Campus and the Flatirons Campus.

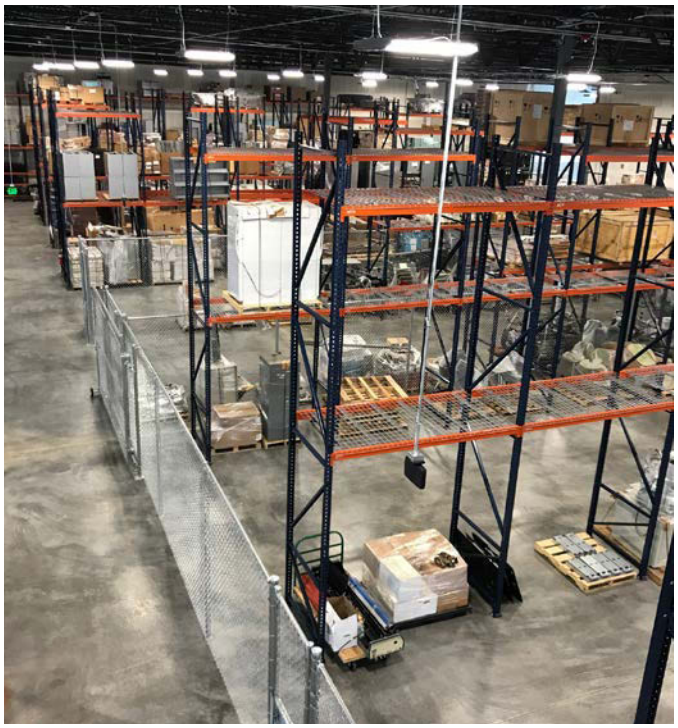
Wildlife

Although the site was heavily grazed by cattle before 1975, surveys conducted since then have identified several species of mammals that use vegetation and other habitat at the Flatirons Campus. Amphibians, reptiles, and numerous species of birds have been documented in surveys conducted since 1992. For details, see Appendix C, Wildlife Species Observed at the STM Campus and the Flatirons Campus.

Denver West Office Park

The Denver West Office Park, located within the City of Lakewood, approximately two miles (3.2 km) east of Golden and 12 miles (19.3 km) west of central Denver, is a relatively flat, landscaped office complex occupied by a number of four-story buildings, parking lots, and common areas. NREL-leased facilities at this location are situated approximately in the geographic center of the development. The Denver West Office Park is bordered on the south by commercial areas (West Colfax strip), and on the west by the Pleasant View residential area, Camp George West facility, and the STM Campus. In addition to office spaces, activities at the Denver West Office Park include research related to fuel and battery characterization, thermal analyses of vehicle cooling loops, vehicle electrical systems analysis, and photo-electrochemical hydrogen production.

Denver West Office Park, Building 16. *Photo by Dennis Schroeder, NREL 44872*



Overlooking the inside of the Golden Warehouse. *Photo by Scott Walters, NREL 61700*

2. Plantae Consulting Services. 2000. *Vegetation Survey: NREL National Wind Technology Center*. Unpublished.
3. ERO Resources. 2018. *Wildlife and Vegetation Monitoring Report at the National Wind Technology Center*. Golden, CO: National Renewable Energy Laboratory. NREL/SR-1900-70362. https://doi.org/10.2172/1457673.

Golden Warehouse

The Golden Warehouse is located at 16201 Table Mountain Parkway in Golden, about 6.1 miles (9.8 km) north of the STM Campus. It is in a commercial area surrounded by residential neighborhoods and small businesses just east of North Table Mountain. It is primarily used as a secure warehouse space. This space replaces the previous Joyce Street Facility warehouse that was vacated in December 2018.

Renewable Fuels and Lubricants Research Laboratory

The Renewable Fuels and Lubricants Research Laboratory is used for research, testing, and support activities related to advanced fuels, engines, and vehicles to objectively evaluate performance, emissions, and energy efficiency impacts, including the evaluation and development of heavy-duty hybrid vehicles. The laboratory consists of a single-vehicle high bay and a small office area housed within the Regional Transportation District's District Shops and Operations Center at 1900 31st Street in Denver, approximately 12 miles (20 km) east of the STM Campus. The operations center facility occupies approximately 22 acres (9 hectares) and serves as the primary maintenance facility for the Regional Transportation System's bus and light-rail train systems. The area around the facility consists of commercial and light industrial development. The Renewable Fuels and Lubricants Research Laboratory lies on relatively flat terrain with a slight gradient to the northwest. The general area is highly developed with concentrated industrial and commercial activities. Very little natural vegetated habitat exists within the site or in the immediate vicinity. Trees and shrubs line the South Platte River adjacent to the site's southern, eastern, and northeastern boundaries.

A research technician works on an electric vehicle bus at the Renewable Fuels and Lubricants Research Laboratory (ReFUEL).
Photo by Dennis Schroeder, NREL 47590

NREL strives to engineer technologies that minimize impact to the surrounding ecology. *Photo by Dennis Schroeder, NREL 57530*

2 ENVIRONMENTAL MANAGEMENT SYSTEM

NREL's Environmental Management System (EMS) supports the laboratory's commitment to continually improving environmental and sustainability performance by providing environmental stewardship and minimizing the environmental impacts of the laboratory's activities and operations. The EMS integrates environmental protection into daily activities throughout the laboratory, including:

- Protecting and enhancing of vegetation, wildlife, and natural resources
- Practicing pollution prevention
- Complying with environmental requirements
- Continually improving environmental protection and sustainability performance.

The laboratory strives to continually minimize waste and prevent pollution, and thus reduce its environmental footprint. Pollution prevention is implemented through the laboratory's EMS, the hazard identification and control process, and sustainability practices.

ISO 14001: 2015 Certification

NREL's EMS is certified to the International Organization for Standardization (ISO) 14001:2015 standard for environmental management systems. ISO 14001 is a globally recognized standard that defines the structure of an organization's EMS to improve its environmental performance. ISO 14001 requires an organization to identify potential environmental impacts and establish controls needed to minimize impacts, monitor and communicate environmental performance, and establish a formal process for continually improving the system.

2.1 Environmental Management System Structure

The EMS is structured based on a plan-do-check-act continual improvement framework described below and depicted in Figure 1.

Planning

- **Environmental Policy:** NREL states its commitments to the environment through this overarching policy. The policy commits specifically to environmental stewardship, pollution prevention, compliance with legal requirements and voluntary commitment, and continual improvement of environmental and sustainability performance.
- **Environmental Aspects of the Lab:** NREL's environmental aspects (see Figure 2) are those activities, products, or services that are identified annually and that have the potential to interact with the environment. The significance of an identified aspect is determined by assigning a frequency of occurrence and a severity. Using this method, NREL's Environment, Safety, Health, and Quality (ESH&Q) staff review potential impacts to the environment annually, and activities in the EMS are prioritized according to the identified significant aspects. NREL also uses a robust hazard identification and control process as part of its Integrated Safety Management System to manage environmental risks.
- **Legal and Other Requirements:** NREL maintains a formal process to identify regulations and standards that are necessary and sufficient to address specific environmental hazards, including federal laws and regulations, state and local requirements, executive orders, and DOE orders.
- **Objectives and Targets:** Regular planning of activities and programs is necessary to achieve NREL's environmental goals. The laboratory plans, implements, monitors, and reports on environmental stewardship goals and actions to generate continual improvement. For details, see Section 2.3, Performance Indicators and Progress.

Implementing

- **Structure and Responsibility:** NREL policies and procedures establish roles and responsibilities for environmental management within the organization.
- **Competence, Training, and Awareness:** NREL verifies that staff are competent on the basis of education, training, or experience, and the laboratory implements a robust environment, health, and safety training program.
- **Communication:** NREL provides several avenues for communication between the laboratory and the community, including community meetings, lunch-and-learn events, publicly available websites, periodic newsletters, and community mailings. NREL tracks and responds to all environmental concerns through the Public Affairs Office. Internal communication regarding environmental issues is provided via intranet sites, newsletters, emails, meetings, posters, trainings, and personal interaction with ESH&Q staff.
- **Operational Control:** NREL plans and manages operations and activities in line with its environmental policy and objectives. Staff continually identify and review activities that could impact the environment, and engineering and administrative controls are put in place to minimize or avoid impacts to the environment.
- **Document and Records Control:** Policies and procedures ensure the current, correct versions of documents are available for use and that records are maintained to meet requirements.

Figure 1. NREL's continual improvement cycle

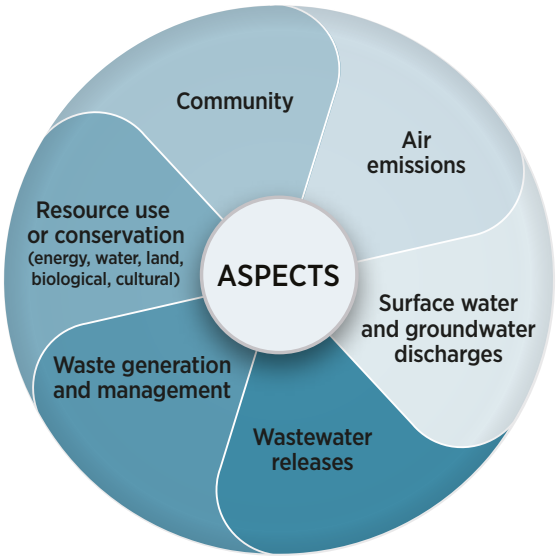


Figure 2. NREL's environmental aspects

Checking and Corrective Action

- **Monitoring, Measuring, and Evaluating Compliance:** NREL monitors key activities, tracks performance and progress toward environmental objectives, and conducts periodic assessments of compliance with legal requirements.
- **Internal Assessment:** NREL periodically conducts assessments to verify that its EMS is operating as intended. A formal system for tracking corrective and preventive actions supports continual improvement of the management system. For details, see Section 2.4.

Feedback

- **Management Review:** NREL's management reviews the EMS regularly to provide feedback and direction to continually improve the environmental performance of the organization.

2.2 Pollution Prevention

NREL has made a formal commitment to pollution prevention through its laboratory-wide environmental policy. The laboratory fulfills this commitment by implementing various controls to reduce the potential environmental impacts of laboratory operations, including NREL's use and storage of chemicals and fuels, as well as laboratory activities such as employee commuting and travel, and energy and water use. NREL's hazard identification and control process helps staff regularly identify opportunities to prevent pollution, and formal pollution prevention assessments are conducted periodically to identify opportunities to reduce pollution and improve program effectiveness. Though most of NREL's environmental management programs were established to meet compliance requirements, many of the programs go beyond compliance requirements and contribute to continual improvements of the lab's environmental performance.

2.3 Performance Indicators and Progress

Each year, NREL develops measurable goals for environmental improvement and identify them in two documents:

- **Performance Evaluation and Measurement Plan:** This plan establishes key priorities and provides specific objectives, expected outcomes, and measures of performance for managing and operating NREL. Each fiscal year, the laboratory and the DOE Golden Field Office collaborate to develop the performance objectives.
- **Site Sustainability Plan:** This plan supports DOE's sustainability goals. The results of implementing the plan are presented in Section 3.1, Sustainability Goals.

Goals are owned by individuals and groups throughout the laboratory. Progress on each goal is tracked throughout the year and results are reported annually. Some examples of performance related to these goals in 2019 are described in Table 1.

Reducing Pollution

Examples of positive impacts of reducing pollution from NREL's activities include:

- Replacing toxic chemicals with safer alternatives where possible to reduce potential exposure to employees, the public, and local ecosystems
- Choosing bio-based and recycled-content products to reduce impacts on natural systems
- Encouraging employees to telecommute or take alternative transportation, and supporting web-based meetings to reduce traffic, air pollution, and health effects on surrounding communities
- Using sustainable, low-energy, and low-water use designs for buildings to reduce greenhouse gas (GHG) emissions and use of Colorado's limited water supplies
- Performing waste audits in facilities to improve diversion of materials from the waste stream to recycling/reuse streams.

A member of NREL's Office of Security and Emergency Preparedness staff sits in one of the laboratory's hydrogen-fueled vehicles that the office's team has been using on the STM Campus.
Photo by Werner Slocum, NREL 54854

Table 1. Environmental Goals Met and Achievements in 2019

2019 Goal(s)	2019 Examples of Achievements	Goal Met?
Provide a comprehensive, effective, and responsive environmental management program	Demonstrated a shared commitment to efficiency, excellence, and compliance with requirements • Completed a wetland delineation to support a future request for an approved jurisdictional determination from the U.S. Army Corps of Engineers • Developed a drinking water sampling and analysis program for aging buildings to ensure building infrastructure is not contributing to a decline in acceptable water quality • Hosted a peer review to evaluate the effectiveness and implementation of environmental programs Shared successes, best management practices, expertise, and lessons learned to promote excellence and collaboration in environmental performance • Provided a bat call analysis for U.S. Geological Survey bat deterrent studies at the Flatirons Campus • Led Earth Week walks to the mesa top and Lena Gulch and hosted a talk on ancient soils at the Flatirons Campus • Participated in monthly conference calls with other DOE national laboratories • Collaborated with DOE Headquarters, the U.S. Fish and Wildlife Service Washington D.C. Office of Migratory Birds, and Pacific Northwest National Laboratory to develop a guidance document for architects; the document is intended to combine bird-friendly design with energy efficiency • Provided guidance, education, and relevant information to assist staff in planning, project execution, and adhering to requirements. • Updated the spill prevention control countermeasures training to include modern graphics, improve interaction with attendees, focus on spill response actions needed, and enable online registration • Developed an online National Environmental Policy Act (NEPA) training for staff that support NEPA evaluations, and a NEPA general awareness training for all interested staff • Provided training sessions to NREL staff on snake ecology and taxonomy to minimize injuries to snakes and to enhance safety awareness of responders during snake relocation activities • Developed a refrigerant management training program for staff who service refrigerant-containing appliances	Yes

2.4 Assessment and Improvement

Assessments support the continual improvement of environmental management. Periodic assessment of the EMS and its components provides assurance that the EMS continues to be an effective tool to achieve and maintain compliance with regulatory and legal requirements, meet the established environmental goals of the laboratory, and demonstrate to ourselves and others that NREL is "walking the talk."

Internal and external assessments are performed to evaluate the functionality of NREL's EMS:

- Internal assessments are performed regularly to evaluate consistency of the EMS with the ISO 14001 standard, legal, and other requirements.
- Periodically, external third-party assessments may be conducted by technical experts for specific components of environmental programs as part of continual improvement efforts. Annual surveillance assessments and triennial recertification assessments are conducted for the EMS as a whole to maintain ISO certification.

Improvements are developed and implemented as needed based on the results of each assessment performed.

The following assessment activities took place in 2019 and have allowed NREL to enhance program effectiveness and make substantial environmental performance improvements:

- **Internal Assessments:** Separate internal assessments were completed for contractor assurance and NEPA program management. Each assessment involved interviews with staff and reviews of relevant procedures and records. The contractor assurance assessment resulted in three opportunities for improvement regarding internal audit, corrective action management, and compliance obligation assurance. The NEPA program management assessment identified one nonconformity and three opportunities for improvement regarding operational planning and control and documentation. Actions to address the nonconformities and opportunities for improvement have been completed.
- **External Assessments:** NREL underwent a maintenance assessment to verify conformance to the ISO 14001:2015 standard. The assessment was conducted by a team of external auditors and included several visits of the laboratory's facilities, interviews with staff at all levels of the organization, observations of processes in place, and reviews of documents and records. The assessment resulted in 13 system strengths, no nonconformities, and four opportunities for improvement. Corrective actions addressing three of the four opportunities for improvement have been completed, and one remains in progress.

Benefits of the EMS to NREL

- **Reduced Risk to Facility and the Organizational Mission:** NREL's Hazard Identification and Control procedure incorporates an environmental risk assessment. System improvements also support the use of requirements to reduce the risk of noncompliance and potential enforcement actions.
- **Improved Fiscal Efficiency and Cost Avoidance:** Cost savings are realized through energy efficiency projects, new renewable energy installations, waste reduction and recycling, and reduced environmental incidents such as spills.
- **Greater Understanding and Recognition of Environmental Issues at all Levels of the Organization:** Staff are made aware of the potential environmental impacts from their work activities through the postings on the NREL intranet; new employee orientation and activity-specific trainings; published policies and procedures; management communications; sustainability communications; and special events such as Staff Awards (an annual employee recognition event), Earth Day, and Bike to Work Day. Improved awareness of environmental issues supports environmental performance throughout the laboratory.
- **Empowerment of Individuals to Contribute to the Betterment of the Organization's Environmental Footprint:** Staff members are empowered to reduce the laboratory's environmental footprint by participating in programs and events for recycling single-stream materials, batteries, electronic equipment, and shredded paper, as well as a composting program.
- **Integration of Environment into the Organizational Culture and Operations:** NREL strives to maintain a high level of awareness in the laboratory about safety, health, and environmental responsibilities. This awareness is supported through regular communications from executive management, training, inspections, and risk assessments.
- **Integration of Environment into Real Property Asset Management:** NREL includes environmental considerations into long-term planning for both the STM Campus and the Flatirons Campus. Long-term site plans consider wildlife movement across the site, surface water management, and climate change impacts.
- **Improved Community Relations:** The laboratory works to improve community relations by responding to and tracking all community input through phone calls, email, and community meetings, and soliciting feedback from stakeholders through the NEPA process. NREL takes proactive measures to engage the community with public tours, newsletters, and mailings to neighborhoods near its facilities.
- **Improved Effectiveness in Overall Mission:** NREL's EMS supports the organization's overall mission and improves effectiveness by systematically addressing environmental opportunities and risks, ensuring compliance with regulations, and implementing voluntary commitments to achieve superior performance.
- **Improved Collaborative Conversation with Other Groups:** The laboratory actively collaborates with stakeholders on environmental issues, such as sustainability, renewable energy, and resource conservation and management. This includes cooperating with other agencies in controlling noxious weeds and the management of conservation areas.

2.5 2019 Awards and Recognition

In 2019, NREL received several awards and recognition of its environmental and sustainability achievements, including those described in this section.

Green Electronics Council Award

In 2019, NREL received the Five-Star EPEAT Purchaser Award from the Green Electronics Council for 2018 EPEAT purchases. NREL is committed to purchasing products designated by EPEAT, ENERGY STAR, and the Federal Energy Management Program, whenever feasible, to continue to positively impact the environment through these purchases.

DOE GreenBuy Superior Award

NREL and the DOE Golden Field Office maintained an award from DOE for demonstrating leadership and continuous improvement in transitioning to more sustainable products. The GreenBuy Award Program recognizes DOE sites for excellence in "green purchasing" beyond minimum compliance requirements. All federal agencies, including DOE, are required to purchase products that are energy-efficient, water-efficient, made from bio-based or recycled content, and are nontoxic or less-toxic than conventional alternatives. Sites that earn the GreenBuy Gold Award multiple times will qualify for these new awards. The Superior level recognizes sites that earn the GreenBuy Gold Award five times.

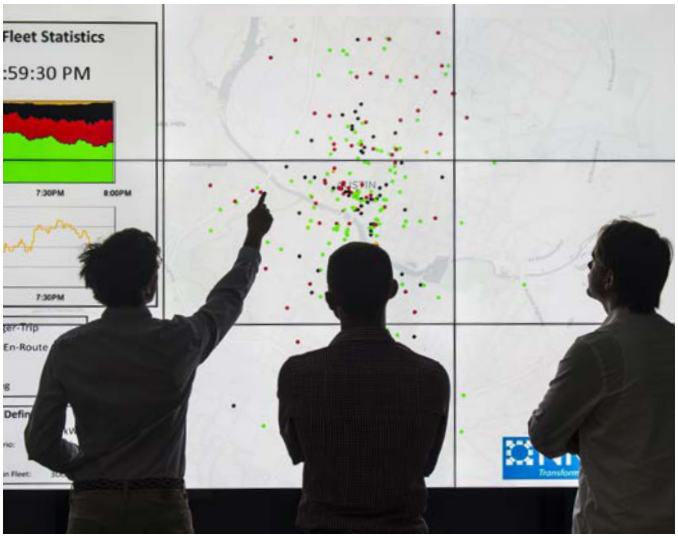
Colorado Environmental Leadership Program Gold-Level Leader Recognition

The Colorado Environmental Leadership Program[4] recognizes facilities that voluntarily:

- Exceed regulatory requirements
- Implement an environmental management system that focuses on incorporating environmental considerations into normal management processes and improving internal environmental management effectiveness
- Work closely with their communities
- Establish three-year goals focusing on measurable results.

NREL maintained its status as a Colorado Environmental Leadership Program Gold-Level Leader, the highest level awarded by the program. The Colorado Environmental Leadership Program is a voluntary partnership of the Colorado Department of Public Health and Environment (CDPHE) and participating private and public Colorado facilities. It is intended to recognize environmental leadership and performance.

In early 2004, NREL was accepted into the program as a Gold-Level Leader and has maintained this leadership level.



NREL researchers analyze the mobility and grid impacts of simulated electric-vehicle fleets' response to real-world transportation demands.. *Photo by Dennis Schroeder, NREL 57502*

As a component of program membership, NREL's voluntary environmental performance goals, described above, further enhance operations and EMS and pollution prevention performance at the laboratory.

2.6 Integrated Environmental Stewardship in Construction Management

NREL designs, builds, and refurbishes facilities using an integrated approach that allows the laboratory to achieve its mission needs while addressing environmental, safety, health, and community considerations.

Project Planning and Design

An interdisciplinary team comprised of members of the laboratory's research, facilities and operations, and DOE Golden Field Office staff collaborates on projects beginning with conceptual planning and design selection, and continuing through construction. Project staff facilitate the identification and inclusion of environmental and sustainable requirements, and best management practices into project designs.

In 2019, NREL coordinated with DOE to conduct environmental compliance field work during design and construction of a 115-kilowatt transmission line for the Flatirons Campus power generation upgrade project. Preconstruction surveys of wetlands, wildlife, and cultural resources were completed and resulted in design alterations that avoided placing poles in wetlands and adding bird diverters—visual aids for birds

4. Learn more about this voluntary program at the state's Environmental Leadership Program website: https://www.colorado.gov/pacific/cdphe/environmental-leadership-program.

to avoid collision with cables—along the transmission line route. DOE and NREL informally consulted with the U.S. Fish and Wildlife Service (USFWS), U.S. Army Corp of Engineers, and the Colorado State Historic Preservation Office, and letters of concurrence were received before construction began.

Environmentally Responsible Construction Practices

During construction projects, DOE and NREL staff participate in weekly construction team meetings, monitor performance criteria, and provide ongoing feedback to project teams regarding environmental management. Environmentally responsible construction practices include reviewing preconstruction project plans, performing nesting bird surveys before commencing earth-disturbing activities, using a "plan of the day" to coordinate and control activities, implementing stormwater controls before starting excavations, tracking waste diversion, properly storing hazardous materials, and controlling dust. Minimizing impacts to wildlife is a consideration for all construction projects.

In 2019, NREL contractors installed wildlife ramps in open construction trenches to provide small wildlife with routes to escape. Additionally, stockpiled dirt gathered from previous construction activities at the Flatirons Campus was used to create a berm around the new substation on the campus; doing so eliminated truck traffic and the fuel and air emissions associated with obtaining dirt off-site.

2019 Accomplishments and Highlights

- Maintained certification to the 2015 version of the ISO 14001 standard. An external third-party assessment verified that the laboratory meets the requirements of the standard and demonstrates our commitment to environmental stewardship.
- Conducted an internal contractor assurance assessment which resulted in three opportunities to improve internal audits, corrective action management, and compliance obligation assurance. And an internal NEPA program management assessment was conducted and identified one nonconformity and three opportunities for improvement regarding operational planning and control and documented information. Actions to address the nonconformities and opportunities for improvement have been completed.

Benefits of the EMS to the Environment

- **Improved Overall Compliance Management:** NREL maintains a formal process to identify regulations and standards that are applicable to the laboratory, including federal laws and regulations, state and local requirements, executive orders, and DOE orders. In addition, compliance with these requirements is regularly reviewed through various mechanisms, including internal assessments, inspections, and monitoring.
- **Personnel Health and Safety:** Continually improving environment, safety, health, and quality management helps make NREL a safer, more environmentally responsible workplace and enhances the quality of our work processes.
- **Pollution Prevention:** Staff regularly identify opportunities to prevent pollution through NREL's hazard identification and control process. Resources are dedicated to sustainable operations and pollution prevention through the laboratory's sustainability efforts.
- **Improved Air and Water Quality:** EMS goals related to using alternative energy sources, using clean-burning fuels, and minimizing the quantity of chemicals used on-site all contribute to improved air quality. NREL continually strives to protect water quality both on-site and off-site by refining and implementing requirements related to the management of runoff, facility operations, and outdoor storage and use of materials throughout facility grounds, including at temporary construction sites.
- **Improved Hazardous Material, Hazardous Waste, and Solid Waste Management:** Hazardous material tracking through NREL's chemical inventory reduces the purchase of new supplies by allowing staff to determine whether a needed chemical is already on-site; this in turn minimizes the generation of hazardous waste. The laboratory has averaged higher than a 75% landfill diversion rate for solid waste for several years, which greatly exceeds DOE goals for waste diversion.
- **Increased Conservation of Water, Natural Resources, Energy and Fuel:** The laboratory sets goals for water, energy, and fuel usage annually and monitors progress toward each throughout the year.
- **Reduced Number of Operating Permits Needed:** Implementation of the EMS provides a mechanism to identify, evaluate, and implement pollution prevention opportunities, including waste minimization, product substitution, and process modification. Such efforts can reduce the number of regulatory requirements that the laboratory must meet.

NREL employees are encouraged to use alternate forms of commuting transportation. *Photo by Dennis Schroeder, NREL 34020*

3 SUSTAINABILITY

NREL pursues sustainability in all laboratory operations and strives to minimize the environmental impacts of doing business. As one of the nation's foremost scientific institutions, the laboratory embraces the best in energy and ecological conservation practices, setting the standard for the wise use of natural resources. As a leader in sustainability, NREL's goal is to minimize the use of energy, materials, and water while conducting clean energy research. In all site development, opportunities to integrate energy efficiency and renewable energy, high-performance buildings, and sustainable transportation options are sought. NREL's commitment to sustainability supports the laboratory's success by applying what is learned, through research and development, to site facilities and infrastructure systems.

3.1 Sustainability Goals

In accordance with DOE Order 436.1, *Departmental Sustainability*, NREL develops a site sustainability plan every year to report on past performance and set goals for the coming year. These performance goals are integrated with the laboratory's EMS.

To meet DOE sustainability performance goals, sustainability considerations are incorporated into operations including:

- Energy, water, and waste management
- Building design, construction, and ongoing maintenance
- Environmental management planning
- Resilience planning
- Measurement and tracking of environmental objectives, targets, and actions
- Awareness and engagement of staff and community members.

NREL's progress in meeting the sustainability performance goals in 2019 is presented in Table 2.

Table 2. Sustainability Goals and Performance Summary

DOE Goal	Current Performance	Status
Multiple Categories		
Year-over-year[a] Scope 1 and Scope 2 greenhouse gas (GHG) emissions[b] reduction from a FY 2008 baseline	Reduction of GHG emissions is no longer a requirement, but attempts to continue reducing emissions each year is encouraged. NREL will continue exploring opportunities to increase on-site use of renewable energy.	N/A
Year-over-year Scope 3 GHG emissions[c] reduction from a FY 2008 baseline	Reduction of GHG emissions is no longer a requirement, but attempts to continue reducing emissions each year is encouraged. NREL will continue exploring opportunities to increase on-site renewable energy.	N/A
Energy Management		
30% energy use intensity (i.e., British thermal units per gross square foot) in goal-subject buildings by FY 2015 from a FY 2003 baseline and 1% year over year thereafter	For the FY 2019 reporting year, energy use intensity decreased by 53% from a FY 2003 baseline, but increased by 10% from FY 2018.	Goal met
Continuous (four-year cycle)[d] energy and water evaluations per Energy Independence and Security Act, Section 432	Energy and water audits were conducted for the Flatirons Campus 2.5-MW dynamometer, 5-MW dynamometer, Administration Building, and Structural Testing Laboratory.	Goal met
Metering of all individual buildings for electricity, natural gas, steam, and water use, where cost-effective and appropriate	95% of NREL's buildings have energy meters,[e] including electricity, natural gas, and renewables where appropriate. 100% of NREL's buildings have chilled water meters. 100% of NREL's buildings have hot water meters. (NREL does not use steam.) 95% of NREL's buildings have potable water meters.	On track to meet goal
Water Management		
20% reduction of potable water intensity (gallons per gross square foot) by FY 2015 from a FY 2007 baseline	For the FY 2019 reporting year, potable water intensity decreased by 12% from a FY 2007 baseline, but increased by 10% from FY 2018.	Goal not met
Year-over-year reduction in industrial, landscaping, and agricultural nonpotable freshwater consumption in gallons; no set target	NREL does not use industrial, landscaping or agricultural nonpotable freshwater.	N/A
Waste Management		
Diversion of at least 50% of nonhazardous solid waste, excluding construction and demolition debris, sent to treatment and disposal facilities	For the FY 2019 reporting year, 65% of waste was diverted from municipal landfills.	Goal met
Year-over-year reduction of construction and demolition materials and debris sent to treatment and disposal facilities; no set target	For the FY 2019 reporting year, 96% of construction and demolition waste was diverted.	Goal met

DOE Goal	Current Performance	Status
Fleet Management		
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; maintain 20% reduction thereafter	For the FY 2019 reporting year, DOE will report on these goals as a summary across all DOE facilities rather than on an individual site basis.	N/A
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter	For the FY 2019 reporting year, DOE will report on these goals as a summary across all DOE facilities rather than on an individual site basis.	N/A
75% of light-duty vehicle acquisitions to consist of alternative fuel vehicles	For the FY 2019 reporting year, DOE will report on these goals as a summary across all DOE facilities rather than on an individual site basis.	N/A
Renewable Energy		
"Renewable electric energy" is required to account for not less than 30.5% of a total agency electric consumption by the end of FY 2019.	For the FY 2019 reporting year, 28% of electricity used by NREL was renewable electric energy, including renewable energy credits.	Goal not met[f]
Continued achievement of year-over-year increase in nonelectric thermal usage[g]	For the FY 2019 reporting year, 30% of the laboratory's' energy consumed was from renewable sources, including thermal energy and renewable energy credits.	N/A
Sustainable Buildings		
15% (by building count) of owned existing buildings compliant with the revised Guiding Principles for High-Performance and Sustainable Buildings by FY 2020, with annual progress thereafter	As of the FY 2019 reporting year, 38% of NREL's buildings meet High-Performance and Sustainable Buildings guidelines.	On track to meet goal
Net Zero Buildings: 1% of a site's existing buildings (>5,000 gross square feet) should be energy, waste, or water net-zero buildings by FY 2025	One building (5%) is net-zero energy (i.e., operated as net-zero energy half the year)[h].	On track to meet goal
All new buildings (>5,000 gross square feet) entering the planning process designed to achieve energy net-zero beginning in FY 2020	All new NREL buildings entering the planning process will be designed to achieve energy net-zero where feasible.	On track to meet goal
Increased regional and local planning coordination and involvement	NREL staff participated in regional events to promote alternative commuting including Bike to Work Day[i] and Go-Tober.[j] The laboratory contributed to the Colorado governor's Climate Resilience Working Group.	Goal met

DOE Goal	Current Performance	Status
Acquisition and Procurement		
Promotion of sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred[k] and bio-based provisions and clauses are included in all applicable contracts	As of the FY 2019 reporting year, 100% of NREL's contracts contain sustainability provisions.	Goal met
Measures, Funding, and Training		
Implementation of annual targets for sustainability investment with appropriated funds and/or finances contracts in FY 2019 and annually thereafter	NREL has explored the use of economically feasible options to improve energy performance, including energy-saving performance contracts and other alternative financing mechanisms.	Goal met
Electronic Stewardship		
95% of eligible acquisitions each year to be EPEAT-registered products	For the FY 2019 reporting year, 96% of eligible acquisitions were EPEAT-registered products.	Goal met
Enabling of power management for 100% of eligible PCs, laptops, and monitors	For the FY 2019 reporting year, power management was enabled for 100% of eligible devices.	Goal met
Enabling of automatic duplexing for 100% of eligible computers and imaging equipment	For the FY 2019 reporting year, automatic duplexing was enabled for 100% of eligible devices.	Goal met
End of Life: 100% of used electronics are reused or recycled to use environmentally sound disposition options each year	For the FY 2019 reporting year, 100% of electronics were reused or recycled.	Goal met
Establishment of a power usage effectiveness (PUE) target for new and existing data centers; NREL's target: average annual PUE of ≤1.20	The Research Support Facility data center had an average PUE of 1.20. The laboratory's High-Performance Computing Data Center in the Energy Systems Integration Facility had an average PUE of 1.03.	Goal met
Organizational Resilience		
Discussion of overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols	NREL developed a dynamic master plan for both the STM Campus and the Flatirons Campus that will expand opportunities for alternative energy exploration. The laboratory conducted an assessment of cybersecurity systems for the protection of distributed energy resources. NREL conducted an assessment of its Continuity of Operations Plan. The laboratory initiated an education program called Ready NREL to raise staff awareness of emergency planning and response topics. The laboratory began implementing enhanced aspects of the public address systems at both the STM Campus and the Flatirons Campus.	Goal met

See footnotes on next page.

3.2 Resilience Planning

NREL is proactively engaged in mitigation and adaptation strategies to manage the risks that extreme events pose to laboratory operations. Improving operational resilience ensures continuity for the laboratory to achieve its mission.

From the Energy Systems Integration Facility (ESIF) Control Room, ESIF staff explain cybersecurity and resilience research being conducted at NREL. *Photo by Dennis Schroeder, NREL 59875*

2019 Accomplishments and Highlights

- Developed master plans for expansion of facilities and infrastructure at the STM Campus and the Flatirons Campus. Key areas of focus were the inclusion of buildings that can function independently of the STM Campus' central heating distribution plant and development of first-of-its-kind resilience technology that incorporates systems to validate technologies' performance through research studies.
- Conducted an assessment of NREL's cybersecurity systems for the protection of distributed energy resources. The assessment included an evaluation of management system controls associated with multiple renewable energy sources used at both the STM Campus and the Flatirons Campus, as well control systems located in facilities that are independent of the STM Campus central plant.
- Participated in regional working groups and provided technical expertise to state and federal groups to further their resilience planning. These groups included the Colorado Resiliency Institutionalization Project, the State of Colorado Resilience Working Group, the Federal Emergency Management Program, and the U.S. Department of Homeland Security.

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[a] A year-over-year calculation compares a statistic for one year to the same statistic for the previous year.

[b] Scope 1 emissions (Direct GHG) are emissions from sources that are owned or controlled by an organization. Examples of such sources at NREL include fuel used for comfort heating equipment, fleet vehicle gasoline or other fuels, and some cryogenic materials used in laboratory experimental processes.

Scope 2 emissions (Energy Indirect GHG) are defined as emissions from the consumption of purchased electricity, steam or other sources of energy generated upstream from an organization. An example of such sources at NREL is grid electricity used to power buildings and laboratory experiments.

[c] Scope 3 emissions (Other Indirect GHG) are defined as emissions that are a consequence of the operations of an organization but are not directly owned or controlled by the organization. Examples of such sources at NREL include fuel use associated with employee commuting and business travel, and waste being sent to landfills.

[d] Energy Independence and Security Act Section 432 requires that, at a minimum, buildings representing at least 75% of total energy consumption undergo energy and water audits every four years. DOE sites are responsible for ensuring facilities are audited on a four-year cycle.

[e] This goal was reinterpreted in 2019 to include all site buildings, not just STM Campus buildings, thus reducing the laboratory's goal attainment from 100% in FY 2018 to 95% in FY 2019.

[f] Goal and allowable means of achieving goal were changed by the federal Council on Environmental Quality near the conclusion of the FY 2019 reporting year. Before the change, NREL had met the previous goal of obtaining at least 7.5% of electric energy consumption from renewable sources.

[g] A goal for nonelectric thermal usage has not been set. However, the federal Office of Management and Budget intends to rate nonelectric thermal usage on a pass/fail basis on its energy dashboard for all federal facilities.

[h] In FY 2019, the first and second phases of construction of the Research Support Facility (RSF 1 and RSF 2) were combined in DOE's Facilities Information Management System and are now referred to as one building, the Research Support Facility. The number, and consequently the percentage, of site buildings meeting the net-zero goal decreased from FY 2018.

[i] Bike to Work Day is an annual Denver-area event held the fourth Wednesday in June that encourages people who normally drive alone to work to ride their bicycles instead.

[j] Go-Tober is an annual competition among employers in the Denver area that encourages employees to try different ways of getting to and from work during the entire month of October.

[k] The BioPreferred Program is a U.S Department of Agriculture-led initiative that aims to assist in the development and expansion of markets for bio-based products.

Blue flax (*Linum lewisii*) at the STM Campus.
Photo by Werner Slocum, NREL 56740

4 COMPLIANCE SUMMARY

NREL is subject to many federal and state laws and regulations, executive orders, and DOE orders and memoranda of understanding with government agencies. By observing these rules and regulations, NREL continues its excellent record of environmental compliance.

Table 3 includes a brief description of the statute or regulation and how compliance requirements were met this year. Detailed information for each area of compliance is found in the referenced sections of this report. For details, see Appendix B, Environmental Permits, Registrations, and Notifications.

Table 3. Federal, State, and Local Environmental Laws and Regulations and Compliance Status Applicable to NREL

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
Report	DOE Order 231.1B, *Chg 1, Environment, Safety and Health Reporting*, was implemented to ensure DOE receives timely, accurate information about events that have affected or could adversely affect the health and safety of the public, workers, the environment, or the operations of DOE facilities. The order requires that DOE facilities report specific site environmental information annually, including environmental management performance, environmental occurrences and response, compliance with environmental standards and requirements, significant programs and efforts, and property clearance activities for property contaminated with radiological materials.	NREL reports annually via this Environmental Performance Report.	DOE: DOE Order 231.1B, *Chg 1*
EMS and Sustainability	Executive Order 13834, *Efficient Federal Operations*, was established May 17, 2018 and references requirements established by the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007. It requires federal agencies to meet statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment. DOE has established goals that accomplish those objectives. DOE Order 436.1, *Departmental Sustainability*, requires that the laboratory implement an EMS that conforms to the ISO 14001 structure. The EMS is implemented as part of a DOE-required Integrated Safety Management System, which systematically integrates safety and environmental protection into management and work practices at all levels to protect the public, the worker, and the environment.	Each year, a site sustainability plan is developed to report on past performance and set goals for the coming year. These performance goals are integrated with the laboratory's EMS. NREL's EMS is certified to the ISO 14001:2015 standard for environmental management systems; it has been certified to ISO 14001 since 2011. Annual assessments verify that NREL meets the ISO standard and is continually improving performance.	Executive Order: EO 13834 DOE: DOE Order 436.1
Resilience Planning	DOE Order 436.1 requires facilities to annually develop a site sustainability plan which facilitates identifying and addressing opportunities for resiliency.	The laboratory continued to enhance resilience through the master planning process, by conducting an assessment of cybersecurity management and developing a staff education program to raise awareness of the need for emergency planning and response. The laboratory continued to participate in regional resilience working groups and provided technical expertise to state and federal groups to further resilience planning efforts.	Executive Order: EO 13834 DOE: DOE Order 436.1

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
Air Quality	The Air Pollution Control Division of Colorado Department of Public Health and Environment (CDPHE) administers the federal Clean Air Act implementing regulations for all point sources (facilities or other types of operations) in Colorado, under authority delegated by the U.S. Environmental Protection Agency (EPA). Categories of regulated air pollutants include criteria air pollutants, hazardous air pollutants (HAPs), ozone-depleting substances, and GHGs. For facilities and stationary sources that emit criteria air pollutants and hazardous air pollutants, there are both federal and state requirements for permitting, reporting, emission controls, emission limits, and operations, depending on the source, type, and amount of air pollutants emitted. Generally, these requirements become stricter as the quantity of air pollutants emitted increases or as the air pollutants have a higher potential for harm or adverse effect. GHGs emitted by certain facilities are required by EPA regulations to be tracked and reported if the emissions are greater than 27,557 U.S. tons (25,000 metric tons [MT]) of carbon dioxide-equivalent (CO_2e) per year. The purpose of this reporting is to better identify the actual emissions of such gases across the United States and provide the EPA with data on which to base future GHG regulations. Reporting and permitting of GHGs may be required under the EPA Prevention of Significant Deterioration regulation, Title V Tailoring Rule, and the EPA Greenhouse Gas Mandatory Reporting Rule, depending on the amount of GHGs emitted. Additionally, permits for major emissions sources (greater than 100 U.S. tons [90.7 MT] per year of a criteria pollutant) may be required to include GHGs in the permit if CO_2e emissions are greater than 100,000 U.S. tons (90,718 MT) per year. EPA's Protection of Stratospheric Ozone (40 Code of Federal Regulations [CFR 82]) includes repair, servicing records and other requirements for appliances containing more than 50 pounds (23 kilograms [kg]) of all regulated refrigerants, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and hydrofluoroolefins (HFOs). Appliances containing 5 or more pounds (2.3 kg) of these refrigerants are subject to end-of-life refrigerant recovery, recycling, and documentation requirements. There are several state air regulations for sources of particulate pollution, including large construction sites and street sanding operations in the winter. Particulate emissions, such as dust from construction sites larger than 25 acres (10.1 hectares), or occurring for more than six months, are subject to state fugitive particulate emissions permits. State regulations require federal, state, and local government facilities to track street sanding in the winter and to minimize sand use.	Program activities were in compliance with requirements. NREL did not exceed any air permit standard or other air regulatory requirement at any facility. EPA redesignated the Denver metropolitan area's ozone nonattainment status from "moderate" to "serious," which resulted in a lowering of the major source permitting threshold for nitrogen oxides (NOx) and volatile organic compounds (VOC) from 100 U.S. tons (90.7 MT) per year to 50 U.S. tons (45.4 MT) per year. The STM Campus is now subject to Title V Operating Permit requirements. HAPs emissions for each individual facility were well below the reporting and permitting thresholds of 10 U.S. tons (9.1 MT) per year for each individual HAP or 25 U.S. tons (22.7 MT) per year for all HAPs combined. The annual evaluation of compliance with federal and state facility-wide permitting and emissions-control requirements was completed. All facilities and individually permitted equipment items remain classified as minor sources. An annual street sanding report was provided to the State of Colorado and Jefferson County as required. It confirmed that no sand was used at the STM Campus or the Flatirons Campus. Laboratory CO_2e and GHG emissions were below the federal reporting and permitting threshold of 27,500 U.S. tons (25,000 MT). All equipment registrations, including annual registration renewals, for state-required ozone-depleting substances were completed for the STM Campus and the Flatirons Campus. Refrigerant recovery equipment is no longer required to be registered with the EPA. Five Air Pollutant Emission Notices (APEN) for standby and research power generators were renewed. Four air permits were renewed: (1) construction particulate emissions, (2) the Renewable Fuel Heat Plant (RFHP), (3) the Integrated Biorefinery Facility (IBRF) standby generator, (4) and the Energy Systems Integration Facility (ESIF) Research Generator #3.	National Ambient Air Quality Standards: 40 CFR 50 Ozone-Depleting Substances (ODS): 40 CFR 82 and CDPHE Colorado Code of Regulations (CCR) 1001-19, Reg. 15 New Source Performance Standards: 40 CFR 60 New Source Review, Prevention of Significant Deterioration: 40 CFR 51 Title V: 40 CFR 70 and 71 National Emission Standards for Hazardous Air Pollutants, Hazardous Air Pollutant: 40 CFR 63 and CDPHE 5 CCR 1001-5, Reg. 3 Permitting: CDPHE 5 CCR 1001-5, Reg. 3 Greenhouse Gas: 40 CFR 98 and 40 CFR 51, 52, 70, 71 Street Sanding: CDPHE 5 CCR 1001-18, Reg. 16

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
Drinking Water Quality	The federal Safe Drinking Water Act establishes minimum drinking water standards and monitoring requirements for drinking water supplies. Under this act, the EPA has established allowable levels for contaminants in drinking water known as maximum contaminant levels. The Water Quality Control Division of the Colorado Department of Public Health and Environment (CDPHE) implements the federal Safe Drinking Water Act in Colorado under authority delegated by the EPA.	Program activities were in compliance with requirements. All monitored parameters met applicable requirements. Annual state-required sampling of lead and copper levels in drinking water was performed. All lead sample results were below the maximum allowable concentration in drinking water of 0.015 milligrams per liter (mg/L) and were below the limit at which the chemical analysis method can detect lead of 0.001 mg/L. Copper levels ranged from 0.063 mg/L to 0.441 mg/L, which is far below the maximum allowable concentration in drinking water of 1.3 mg/L. These results were reported to the Water Quality Control Division of CDPHE, as required. Water meters were installed at two buildings on the Flatirons Campus for the purpose of designing and permitting a new on-site wastewater treatment system, and to help identify water-saving opportunities. Average daily drinking water usage was 202 gallons (764 L) per day at the less-populated building, and 282 gallons (1,067 L) per day at the main campus building. A total of 511,740 gallons (1,937,147 L) of drinking water were provided to the Flatirons Campus.	EPA: 40 CFR 141-149 CDPHE: 5 CCR 1002-11 Reg. 11
Groundwater Quality	Colorado groundwater quality standards are established by CDPHE. Permits for groundwater wells are issued by the Colorado Department of Natural Resources. Permits are required for drinking water, water use by geothermal technologies, irrigation, livestock watering, dewatering, monitoring wells, and geothermal well installations.	Program activities were in compliance with requirements. There were no spills or releases that impacted groundwater.	CDPHE: 5 CCR 1002-41 2 CCR 402-2 2 CCR 402-10

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
Surface Water Quality	Surface water quality is controlled through the federal Clean Water Act (CWA), the Energy Independence and Security Act of 2007, and the Colorado Water Quality Control Act. Stormwater discharges resulting from construction activities at federal facilities that disturb one or more acres (0.4 hectares) of land are administered in Colorado by the EPA. To obtain coverage under an EPA Construction General Permit for stormwater discharges, a site-specific stormwater pollution prevention plan must be prepared and a notice of intent must be filed with the EPA. The Water Quality Control Division within CDPHE regulates stormwater discharges at nonfederal facilities within Colorado. For NREL construction projects that occur off federal property, a Colorado Discharge Permit System stormwater permit may be required. Owners and operators of regulated municipal separate storm sewer systems (MS4s) are required to develop a management program to minimize the discharge of pollutants into local bodies of water. The Energy Independence and Security Act requires federal agencies to reduce stormwater runoff from federal development projects to the maximum extent technically feasible. Stormwater runoff levels should reflect predevelopment hydrology, specifically with regard to runoff rate, volume, duration and water temperature. Agencies can comply by using low-impact design elements such as porous pavers, cisterns, and bioswales, or by retaining stormwater runoff and releasing it at predevelopment rates.	Program activities were in compliance with requirements. Periodic stormwater inspections were performed at locations where earth-disturbing activities occurred. The inspections and any resulting maintenance of structural stormwater erosion and sediment controls took place on construction sites operating under an EPA construction general permit, as well as smaller areas where permit coverage is not required but where stormwater best management practices are followed. Development began on several of the MS4 permit program areas intended to reduce the discharge of pollutants in stormwater runoff from the STM Campus. Accomplishments included establishment of a team to guide development and implementation of permit programs, development of various fact sheets to educate staff and contractors, and checklists to ensure protection of water quality is incorporated into site design and construction projects. The notice of intent for an EPA construction general permit for both the Flatirons Campus Improvements, Secondary Feeder and Power Upgrade Project and the STM Campus' SERF and S&TF Landscaping Improvements Project are to remain active through December 31, 2020.	EPA: 40 CFR 122.26 CDPHE: 5 CCR 1002-61, Regs. 38, 61, 65, 93 Executive Order: EO 13834

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
Wastewater	Wastewater is regulated at the federal level under the CWA and at the state level under the Colorado Water Quality Control Act by the Water Quality Control Division of CDPHE. The Metro Wastewater Reclamation District (Metro District) manages wastewater at its treatment plant per federal and state requirements. Domestic and nondomestic wastewater flows are delivered to the Metro District's plant via conveyance systems owned, operated, and regulated by numerous sanitation districts. Nondomestic wastewater discharges to the Metro District must comply with the Metro District's rules and regulations, which incorporate requirements of the CWA. On-site septic systems are regulated by the CDPHE Water Quality Control Division. Inspection and permitting of individual sewage disposal systems have been delegated to Jefferson County by CDPHE.	Program activities were in compliance with requirements. Design of a new on-site wastewater treatment system for the Flatirons Campus was completed and approved by Jefferson County. The new system will replace the existing system, which was installed in 1994 for a much smaller site population.	EPA: 40 CFR 122-136 CDPHE: 5 CCR 1002-62, 63

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
Hazardous Materials Management	Hazardous material management is regulated at the federal level through Superfund Amendments and Reauthorization Act Title III, which is also known as the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986. EPCRA was created to help communities and federal, state, and local governments plan for emergencies involving hazardous substances. It also requires industry to report on the storage, use, and accidental release of hazardous chemicals to federal, state, and local governments. NREL facilities are subject to Sections 302, 304, 311, 312, and 313 of EPCRA. EPCRA Section 302 requires a facility to notify state and local emergency response and planning agencies if any extremely hazardous substances in the facility's inventory are stored in quantities greater than regulatory thresholds. EPCRA Section 304 requires facilities to immediately notify state and local emergency response and planning agencies if there is an accidental spill or release of more than the predetermined reportable quantity. In accordance with Sections 311 and 312 of EPCRA, NREL provides safety data sheets for chemicals stored on-site in quantities greater than regulatory thresholds. In addition, NREL provides inventory reporting for these chemicals in an annual hazardous materials report, called a Tier II report, to state and local emergency response agencies and local fire departments. EPCRA Section 313 requires that a toxic chemical release inventory report be filed with the EPA in the event of a release for any chemical that is manufactured, processed, or otherwise used in quantities exceeding regulatory thresholds. Annual hazardous materials permits are required by West Metro Fire Rescue for the STM Campus and Denver West Office Park. Permits are issued for seven buildings where hazardous materials are stored or used. Before issuing the permits, a representative of West Metro Fire Rescue conducts a walk-through inspection of the entire STM Campus and the NREL building at the Denver West Office Park. The Renewable Fuels and Lubricants Research Laboratory, which is located within the City and County of Denver, is subject to the Denver Fire Department's Hazardous Materials Information System requirements, including permitting, inventory, and annual inspection. This facility's inventory of listed materials, including various fuels such as biodiesel, must be reported to the Denver Fire Department annually. Hazardous materials permits are currently not required at the Flatirons Campus or the Golden Warehouse. Executive Order 13834 states the acquisition and use of products and services are to be in accordance with statutory mandates and applicable federal procurement policies.	Program activities were in compliance with requirements. Section 302 notification was not required. There were no releases of hazardous materials that required reporting under Section 304. In accordance with DOE requirements, NREL screened selected chemicals to confirm that quantities fell below those requiring elevated operational protocols. EPCRA Tier II hazardous materials reports under Section 312 were submitted for two facilities. The reports help state and local emergency response and planning agencies and local fire departments plan for chemical emergencies. Chemicals reported include diesel fuel, petroleum oil, sulfuric acid, and lead contained in sealed lead-acid batteries. A Section 313 Toxic Release Inventory reporting was not required. Hazardous materials permits were acquired for affected facilities.	EPA: 40 CFR 355, 370, 372 Executive Order: EO 13834 DOE: DOE Order 151.1D

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
Hazardous Waste Management	The Resource Conservation and Recovery Act established requirements for the management of regulated waste, including hazardous waste. In Colorado, the Hazardous Materials and Waste Management Division of CDPHE administers requirements under authority delegated by the EPA. Additional requirements for hazardous material transportation are regulated by the U.S. Department of Transportation. NREL maintains unique EPA identification numbers for four of its five facilities: STM Campus, Denver West Office Park, Flatirons Campus, and the Renewable Fuels and Lubricants Research Laboratory. Per state and federal regulations, annual generator notifications are made and applicable fees are paid to the state based on monthly volumes of hazardous waste generated at each facility. EPA has three waste generator classifications: • Large quantity generator • Small quantity generator • Very small quantity generator. Four of five of NREL's sites fall under the very small quantity generator category because they generate minimal amounts of hazardous waste per calendar month. The STM Campus typically produces quantities of hazardous waste well within the small quantity generator category; however, because of pilot-scale research experiments, the STM Campus can episodically elevate to the large quantity generator category in one or more months during the year. Executive Order 13834 states that facilities shall implement waste prevention and recycling measures and comply with federal requirements.	Program activities were in compliance with requirements. Fifteen hazardous waste and five universal waste shipments for off-site disposal and recycling were made across NREL's five sites. Mandatory employee training on hazardous and universal waste management was completed in compliance with state and federal regulations. All regulatory notifications were submitted and applicable waste generator fees were paid. The leased Joyce Street Facility was vacated in 2018, and the EPA identification number is pending termination.	EPA: 40 CFR 260-280 Executive Order: EO 13834 CDPHE: 6 CCR 1007-3
Aboveground Storage Tank Management	Aboveground storage tanks (ASTs) are regulated in Colorado by the Colorado Department of Labor and Employment's (CDLE) Division of Oil and Public Safety (DOPS) under the Colorado AST regulation. Regulations require that ASTs be constructed and installed according to specific standards, that they be regularly inspected with all inspections being documented, and that facilities meeting certain oil storage quantities employ a spill prevention, control, and countermeasures (SPCC) plan to manage oil sources of 55 gallons (208 L) or more.	Program activities were in compliance with requirements. All tanks were inspected to confirm continued adherence to State of Colorado regulations. Annual AST training was provided to 29 staff members identified as having responsibility for operating and fueling ASTs or performing oversight for tank safety and environmental compliance.	CDLE: DOPS Storage Tank Regulations: 7 CCR 1101-14 Rocky Mountain Fire Protection District, West Metro Fire Protection District: International Fire Code, Sections 5003.5 and 5704.2.3.2; National Fire Protection Association 704 (2012 Ed.)

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
Spill Prevention and Response	Oil spill prevention and response is managed at the federal level under the Oil Pollution Prevention Act and Clean Water Act, and at the state level under Colorado Storage Tank Regulations as implemented by DOPS. SPCC plans are required by EPA and Colorado regulations for facilities that meet certain oil storage criteria. In general, facilities that store more than 1,320 gallons (5,000 L) of oil and have the potential for a spill to enter waters of the United States or Colorado waters must have an SPCC plan. SPCC regulations require that any equipment or containers with the capacity to store 55 gallons (208 L) or more of oil be included in the plan. The purpose of the SPCC plan is to prevent the discharge of oil and hazardous substances and minimize the impact of such spills to adjacent waterways.	Program activities were in compliance with requirements. No reportable spills occurred. Seven minor spills of diesel, lubricant, coolant, and hydraulic fluids occurred at the STM Campus, and one spill occurred at the Flatirons Campus. The size of spills ranged from less than 0.25 gallon to 10 gallons (0.95 to 37.9 L), with a total approximate quantity spilled of 37 gallons (140 L). Six of the eight of these spills were from vehicles and mobile equipment, and seven of the eight spills occurred on paved surfaces. Each spill received immediate remedial action and there was no significant impact to the environment. SPCC training is required annually of all staff who manage fuel storage tanks. Fifty-four NREL staff completed the training. The training was also revised to include an updated spill history and emphasize spill prevention and immediate response requirements.	EPA: Oil Pollution Prevention: 40 CFR 112 CWA Section 319 CDLE: DOPS Storage Tank Regulations, 7 CCR 1101-14 CWCC: 25-8-205 CRS.
Radiological Materials and Waste Management	Air emissions are regulated by Section 112 of the Clean Air Act and implemented by the EPA. 40 CFR Part 61 established the National Emission Standards for Hazardous Air Pollutants and its Subpart H specifically sets standards for radiological materials. DOE Order 458.1, *Radiation Protection of the Public and the Environment*, establishes radiation emission limits for DOE facilities. These facilities, including NREL, must annually demonstrate compliance with EPA radiological air standards that limit emissions to amounts that would prevent any member of the public from receiving an effective dose equivalent of 10 millirem (mrem) per year or more. DOE Order 458.1 establishes requirements that must be followed when releasing any radiologically contaminated equipment or real property to another DOE national laboratory, collaborating agency, or outside entity is proposed. These requirements detail the measurable radiological levels that must be verified and documented in order to comply with DOE authorized limits. DOE Order 435.1, *Radioactive Waste Management*, establishes requirements to ensure radioactive waste is managed in a manner that protects the health and safety of workers and the public, and the environment. This is accomplished through systematic planning, evaluation, and documentation of proposed activities that would generate radioactive waste before those activities are authorized to commence.	Program activities were in compliance with requirements. Only small quantities (less than 2 cubic yards [1.5 cubic meter]) of low-level radioactive waste are in storage awaiting off-site disposal. In 2018, two chemical fume hoods and laboratory cabinetry were removed during decommissioning of the laboratory's only low-level radioactive work area. Radiological sampling indicated the items were within limits for release and would not pose a hazard to workers, the public, or the environment. The items are being prepared for off-site disposal in accordance with DOE requirements. In accordance with a federal regulation and DOE order, NREL submitted its annual *Radionuclide Air Emissions Annual Report* to the EPA confirming that the laboratory is in compliance with air emissions standards. For calendar year 2019, the effective dose equivalent of radiation to the public was 0.037 mrem, which is far below the 10 mrem per year limit. No property was either requested or authorized for clearance to be released for reuse or disposal.	EPA: 40 CFR 61, Subpart H DOE: DOE Order 458.1 DOE Order 435.1 Chg 1

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
National Environmental Policy Act	The National Environmental Policy Act (NEPA) requires that federal agencies analyze and disclose the potential environmental impacts of proposed federal actions and alternatives as part of its decision-making process. DOE regulations and orders establish how NEPA is implemented for DOE, and the Council on Environmental Quality reviews and approves federal agency NEPA procedures. Under NEPA, DOE considers the potential impacts to the environment, including natural, social, and economic factors to determine the appropriate level of review for a proposed action. These include categorical exclusions, environmental assessments, and environmental impact statements.	Program activities were in compliance with requirements. A total of 281 documented environmental evaluations were completed; 237 actions were covered by a Programmatic NEPA Determination; and 44 actions were submitted to DOE for review.	Council on Environmental Quality: 40 CFR 1500-1508 DOE: 10 CFR 1021
Wildlife Management	The Migratory Bird Treaty Act (MBTA) of 1918, as implemented by the U.S. Fish and Wildlife Service (USFWS), and the Damage or Destruction of Dens or Nests—Harassment of Wildlife statute as administered by the Colorado Division of Parks and Wildlife, manage the protection of migratory birds. The MBTA and its amendments implement several treaties between the United States, Great Britain, Mexico, Japan, and the former Soviet Union. The MBTA prohibits the taking, killing, or possession of migratory birds, nests, and eggs. The USFWS Service has developed a system of permits for activities that involve the "take" of migratory birds, including those governing scientific collection and bird banding, and lethal and nonlethal measures taken to prevent depredation of agricultural crops and to protect public health and safety. Within Colorado, no wildlife dens or nests, young, or eggs may be damaged or destroyed unless permitted by the Colorado Division of Parks and Wildlife. It is unlawful for any person to willfully harass wildlife, including birds. Under the Memorandum of Understanding between DOE and the USFWS Regarding Implementation of EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, DOE agrees to integrate migratory bird conservation principles, measures, and practices into agency activities and avoid or minimize adverse impacts on migratory bird resources and their habitats. Under the Presidential Memorandum, *Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators*, a Pollinator Health Task Force was created to develop a National Pollinator Health Strategy to enhance pollinator habitat on federally managed lands and facilities, and incorporate pollinator health as a component of all future restoration and reclamation projects.	Program activities were in compliance with requirements. Ground-nesting-bird surveys were conducted before annual mowing, weed control operations, and various research projects at the STM Campus and the Flatirons Campus in compliance with the MBTA.	USFWS: MBTA 16 U.S.C. 703-712 Colorado Division of Parks and Wildlife: CRS 33-6-128 Memorandum of Understanding between DOE and the USFWS Executive Order: EO 13186 Presidential Memorandum: Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
Endangered Species and Species of Concern	The Endangered Species Act (ESA), which is jointly administered by the USFWS and the National Marine Fisheries Service, protects threatened and endangered wildlife and plant species and associated critical habitat. Federal agencies are required to abide by the ESA to ensure their actions do not adversely affect species that are federally listed under the ESA as threatened, endangered, or candidate species. Additional federal and state laws and regulations protect wildlife, such as the Bald and Golden Eagle Protection Act. DOE's formal consultation with the USFWS for the 2014 site-wide environmental assessments for the STM Campus and the Flatirons Campus resulted in an agreed-upon threshold for water usage to limit impacts to the Platte River system. The Colorado Division of Parks and Wildlife maintains a list of endangered, threatened, and wildlife species of concern for Colorado. Furthermore, the Colorado Natural Heritage Program has a list of rare species that is not regulatory in nature but is unique in that it is the only designation besides the ESA's that considers rare plants.	Program activities were in compliance with requirements. No activities were conducted in designated critical habitat for the federally threatened Preble's meadow jumping mouse (*Zapus hudsonius preblei*). The 39.5 million gallons (149.5 million liters) of water used at the STM Campus and the Flatirons Campus were reported to the USFWS.	USFWS: 50 CFR 17 Colorado Division of Parks and Wildlife: 2 CCR 406-10, Article 2 and Article 3
Vegetation Management	The Federal Insecticide, Fungicide, and Rodenticide Act, as implemented by the EPA, regulates the use, storage, and disposal of herbicides and pesticides. For application of certain types of herbicides designated as "restricted use" by the EPA, a certified applicator must be used. In Colorado, the Commissioner of Agriculture develops and implements state noxious weed management plans for three categories of weed species. Class A plants are targeted for eradication. Class B species are subject to management plans designed to stop their continued spread. Class C species are subject to plans designed to support the efforts of local governing bodies to facilitate more-effective integrated weed management on private and public lands. EO 13112, *Invasive Species*, requires the control of invasive species at federal facilities. Importation of regulated plants and animals/organisms from other states and countries requires permitting by the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture. NREL's Biosafety Program manages the importation and use of these materials.	Program activities were in compliance with requirements. At the Flatirons Campus, herbicides were applied to approximately 95.5 acres (38.6 hectares) to control B- and C-listed weeds in May, June, and July, and to 4.5 acres (1.8 hectares) in September. At the STM Campus, herbicides were applied to control A-, B-, and C-listed weeds to approximately 5.8 acres (2.3 hectares) in May and 6.1 acres (2.5 hectares) in July, and to 4.8 acres (1.9 hectares) in September. Leafy spurge (*Euphorbia esula*), a noxious weed species, was identified at the STM Campus and at the Flatirons Campus. The invasive leafy spurge was treated in the past but had not been detected in several years. Additional treatments will continue in 2020. At the close of 2019, NREL held two active APHIS permits for microorganisms imported to the STM Campus from within the United States and from Japan. Two additional permits that had been obtained for imported plant materials were allowed to expire. A permit obtained in 2016 for research related to several organisms imported from Puerto Rico and the U.S. Virgin Islands was terminated.	Executive Order: EO 13112 EPA: 40 CFR 162-171(f) CRS 35-5.5 Department of Agriculture: Federal Noxious Weed Act of 1974 (Public Law 93-629, 88 Statute 2148) Plant Protection Act (Public Law 106-224) Federal Insecticide, Fungicide, and Rodenticide Act 7 USC 136 et seq.

Report Sections	Regulatory Program Description	Compliance Status	Regulator and Requirement
Wetlands and Floodplains	Wetlands became regulated under the 1972 amendments to the Clean Water Act. Wetlands that meet certain soil, vegetation, and hydrologic criteria are protected under Section 404 of the CWA, which is administered by the U.S. Army Corps of Engineers (USACE) and the EPA. Under EO 11990, *Wetlands Protection*, federal agencies must provide leadership and take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. EO 11988, *Floodplain Management*, requires federal agencies to provide leadership and take action to reduce the risk of flood loss; minimize the impact of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains. Counties protect floodplains by mapping 100-year floodplain boundaries within their jurisdiction in coordination with the Federal Emergency Management Agency. Counties then formulate regulations to control the type and amount of development within the designated boundary. Jefferson County requires approval of development proposed in floodplains within its jurisdiction.	Program activities were in compliance with requirements. A wetland delineation was conducted within the Middle Drainage area of the STM Campus. The resulting information will be submitted to the U.S. Army Corps of Engineers in 2020 for a jurisdictional determination and will be used to inform future planning for development of the STM Campus. The existing wetland types identified and associated acreages are listed in Table 9 (Section 9.4).	USACE: CWA Section 404 Executive Orders: EO 11988, EO 11990 DOE: 10 CFR 1022
Cultural Resources	Cultural resources are protected under Sections 106 and 110 of the National Historic Preservation Act, which is administered in Colorado by the Colorado Office of Archaeology and Historic Preservation and the State Historic Preservation Officer. Federal agencies must establish preservation programs—commensurate with their mission and the effects of their activities on historic properties—that provide for the careful consideration of historic properties. Significant cultural resources are either eligible for, or listed in, the National Register of Historic Places. Cultural resources are defined as any prehistoric or historic district, site, building, structure, or object considered important to a culture, subculture, or community for scientific, traditional, religious, or other reason.	Program activities were in compliance with requirements.	Advistory Council on Historic Preservation: 36 CFR 60 36 CFR 63 36 CFR 79 36 CFR 800 16 U.S.C. 470 SHPO: 8 CCR 1504-7

A diesel genset (generator) on top of a fuel tank outside NREL's parking garage at the STM Campus.
Photo by Larry Durbin, NREL 61644

5 AIR QUALITY PROTECTION

Good air quality is fundamental to the overall well-being of individuals and the environment. Each person inhales approximately 3,700 gallons (14,000 L) of air per day, and contaminants that may be present can affect the individuals' health. Air pollutants in the environment also can affect vegetation, aquatic life, and wildlife that may be exposed to those pollutants.

NREL strives to protect air quality and the environment by minimizing air emissions from research and operations activities and employee commuting, tracking air emissions from the larger on-site sources, and meeting federal and state air emissions and permitting requirements. Emitted air pollutants include criteria pollutants (e.g., carbon monoxide, nitrogen oxides, volatile organic compounds, particulate matter, and sulfur dioxide) and non-criteria pollutants (e.g., hazardous air pollutants, GHG compounds, and ozone-depleting substances). Minimizing air emissions generated by the laboratory contributes to the improvement of regional air quality, benefiting both neighbors immediately adjacent to the laboratory and those in the Denver metropolitan area. ESH&Q staff members participate in project planning, safety evaluations, start-up reviews, and operations activities to ensure permit and regulatory compliance and address air quality considerations.

5.1 Criteria Pollutants and Hazardous Air Pollutants

The primary sources of regulated pollutants at NREL are a result of fuel use, chemical use, and facility operations. Sources include process heat boilers, process cooling systems, comfort heating and cooling systems, standby generators, construction and maintenance equipment with gasoline or diesel engines, bench- and pilot-scale research activities using chemicals, and facility operation and maintenance activities.

In December of 2019, an EPA redesignation of the Denver metropolitan area's ozone nonattainment area changed from "moderate" to "serious" because of a failure to meet the

ozone air quality standard. The new designation changed the definition of a major source of nitrogen oxides or volatile organic compound emissions from 100 U.S. tons (90.7 MT) per year to 50 U.S. tons per year (45.4 MT). If major source emissions exceed 50 U.S. tons per year (45.4 MT), a site-wide Title V operating permit must be acquired.

Current maximum potential nitrogen oxides emissions for the STM Campus are reported to be 68.7 U.S. tons per year (62.3 MT). Because this number exceeds the 50 U.S. ton (45.4 MT) per year Title V operating permit threshold, the STM Campus must either obtain a Title V operating permit or reduce emissions. In mid-2019, NREL and DOE began evaluating compliance requirements and potential actions in expectation of this permit change, and permitting action will be required in 2020. NREL has until January 26, 2021 to comply with the change.

A summary of the estimated annual air pollutant emissions for NREL facilities in 2019 is included in Table 4.

5.2 Refrigerants

Refrigerants such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are considered ozone depleting substances (ODS) and are now only available as recycled refrigerants. Non-ODS compounds such as hydrofluorocarbons (HFC) and hydrofluoroolefins (HFOs) have been used to replace ODS refrigerants but are potent GHGs.

NREL uses refrigerant-containing "appliances" such as comfort cooling systems; research environmental chambers and experimental equipment; and small appliances such as refrigerators, coolers, and air conditioners. These appliances contain a variety of refrigerants in varying quantities. Appliances are sealed units that do not normally emit refrigerants. Emissions of refrigerants may occur either as a result of appliance leaks or during servicing activities. NREL follows Colorado and EPA regulations, and strives to minimize the release of refrigerants.

The NREL equipment and refrigerant inventory includes 131 appliances, 20 of which contain 50 or more pounds of refrigerant and are subject to strict requirements. The total inventory of all NREL refrigerants is 8,957 pounds (4,071 kg); of these, 1,150 pounds (523 kg) are ODS and the remaining 7,807 pounds (3,549 kg) are non-ODS that are GHGs.

Additional information about management of NREL's air quality protection program can be found in Appendix A.

2019 Accomplishments and Highlights

- The Jefferson County Health Department, which conducts periodic air inspections for the Colorado Department of Public Health and Environment, inspected permitted sources at the Integrated Biorefinery Facility (IBRF). The inspection included a review of operating records and a visual inspection of the ammonia scrubber, particulate baghouse, and standby generator associated with the IBRF. The inspection identified no compliance issues or concerns.
- Updated the 2019 criteria emission, GHG emission, and refrigerant inventories. The updates resulted in minor changes to each inventory.
- Evaluated six construction and research projects for air emissions; five were research projects and one was a project for demolition of a compressed natural gas fueling station.

Table 4. STM Campus, Flatirons Campus, and Denver West Office Park Estimated Annual Air Pollutant Emissions (in U.S. Tons [MT] Per Year)[a]

Year	Criteria Pollutants					GHGs			HAPs
	CO	NO_x	VOC	PM_{10}	SO_2	CO_2	CH_4	N_2O	Total
2015	6.42 (5.82)	15.49 (14.05)	0.54 (0.49)	3.95 (3.58)	0.45 (0.41)	9,329 (8,463)	0.56 (0.51)	0.30 (0.27)	0.63 (0.57)
2016	5.73 (5.19)	12.94 (11.74)	2.05 (1.86)	1.61 (1.46)	0.16 (0.15)	7,066 (6,410)	0.31 (0.28)	0.15 (0.14)	0.28 (0.26)
2017	5.92 (5.37)	13.63 (12.37)	2.06 (1.87)	2.30 (2.09)	0.24 (0.22)	7,685 (6,972)	0.38 (0.34)	0.19 (0.17)	0.38 (0.35)
2018	7.94 (7.25)	18.73 (17.02)	2.15 (1.95)	3.00 (2.73)	0.41 (0.37)	8,526 (7,751)	0.73 (0.66)	0.22 (0.20)	0.47 (0.43)
2019	8.25 (7.48)	20.43 (18.53)	2.19 (1.99)	3.73 (3.38)	0.50 (0.45)	9,264 (8,403)	0.31 (0.28)	0.27 (0.24)	0.58 (0.53)

[a] CO: carbon monoxide; NO_x: nitrogen oxides; VOC: volatile organic compounds; PM_{10}: respirable particulate matter less than 10 microns in diameter; SO_2: sulfur dioxide; CO_2: carbon dioxide; CH_4: methane; N_2O: nitrous oxide; HAPs: hazardous air pollutants

A bridge and outfall structure consisting of three reinforced concrete pipes spans a portion of Denver West Parkway within the STM Campus. The outfall structure directs stormwater flows to the Central Arroyo Detention Basin. *Photo by Werner Slocum, NREL 61698*

6 WATER QUALITY PROTECTION

Water quality is critical to human health and the health of our natural ecosystems. Water quality protection at NREL falls within four main areas:

- Drinking water
- Groundwater
- Surface water
- Wastewater.

Additional information about program management for each of these four areas can be found in Appendix A.

6.1 Drinking Water

The STM Campus and the Flatirons Campus are provided with potable drinking water by two different means. The STM Campus is serviced by a municipal public water supplier, Consolidated Mutual Water Company, whose source water is primarily stormwater runoff and snowmelt from within the Clear Creek watershed. The Flatirons Campus is not located within the bounds of a municipal public water supply distribution system; instead, treated water is purchased from the City of Boulder and transported by truck to the campus for the employees there. The treated water originates in large part from the Boulder Creek watershed and, to a lesser degree, some watersheds on the western slope of Colorado. The trucked water is transferred to a large holding tank with a capacity of 15,000 gallons (56,781 L). Water is pumped from the holding tank to a 2,000-gallon (7,580-liter) day tank, where chlorine is added to boost disinfectant levels before the water is distributed to campus buildings. (See Figures 3 and 4.)

The State of Colorado permits the Flatirons Campus drinking water system. Weekly monitoring and periodic required sampling are conducted by a subcontractor to NREL that is designated as the "operator in responsible charge" (ORC). Sample analysis is performed by an analytical laboratory contracted to the ORC. Monitoring and sample collection methods, as well as sample handling and laboratory quality control methods prescribed by the State of Colorado and the EPA, are included in the ORC subcontract with NREL and in the ORC's contract with the analytical laboratory.

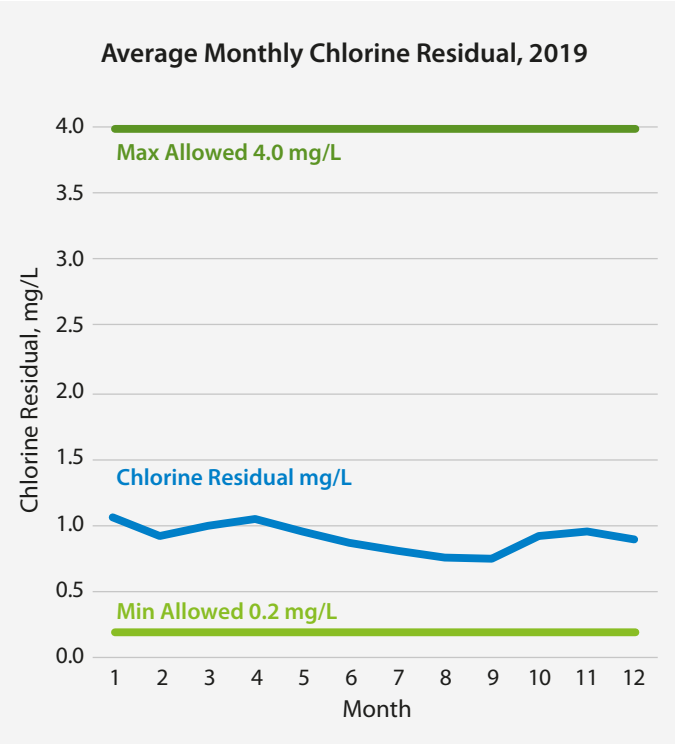


Figure 3. Results of 2019 average monthly chlorine residual monitoring at the Flatirons Campus

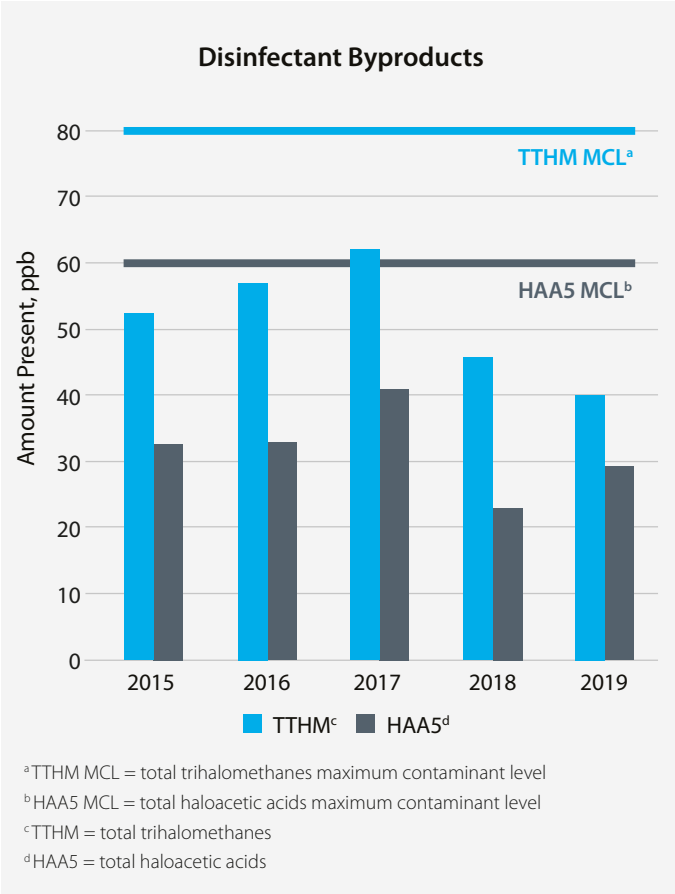


Figure 4. Comparison of disinfection byproducts monitoring at the Flatirons Campus

2019 Accomplishments and Highlights

- Installed water meters in two buildings at the Flatirons Campus for the purpose of designing and permitting a new on-site wastewater treatment system, and to help identify water-saving opportunities.
- Provided 511,740 gallons (1,937,147 L) of drinking water to the Flatirons Campus, which represents a 38% increase in water usage. This increase is attributable to both an increase in Flatirons Campus staff and installation of an irrigation system. Irrigation water usage is expected to decrease in the future, after recently planted low-water vegetation is established.

6.2 Groundwater

The Denver Basin aquifer system underlies an area of approximately 7,000 square miles (1,812,992 hectares) that extends from Greeley south to near Colorado Springs and from the Front Range urban corridor east to near Limon. The aquifer system provides groundwater supplies to urban, rural, and agricultural users. The aquifers within the larger aquifer system, which include the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers, form a layered sequence of rock in an elongated, bowl-shaped structural depression. Both the STM Campus and the Flatirons Campus are located at the western edge of the Denver Basin aquifer system.

The STM Campus overlies the shallowest portions of the Denver, Arapahoe, and Laramie-Fox Hills aquifers. The Flatirons Campus overlies the shallowest portions of the Arapahoe and Laramie-Fox Hills aquifers. The Dawson formation is the shallowest of the Denver Basin aquifers and is the one most relied on aquifers by the groundwater users in the basin. The northern extent of the Dawson aquifer is located approximately 20 miles (33 km) south and east of the STM Campus; consequently, wells drilled at either the STM Campus or the Flatirons Campus would not intersect the Dawson aquifer, nor would a source of contamination on the affect the groundwater quality in this aquifer.

Despite the low likelihood of contaminants reaching the Dawson aquifer, NREL's groundwater management program is focused on controlling potential pollutant sources that could affect this important resource. The program includes careful evaluation of all outdoor projects to eliminate, substitute, or control potential sources of pollution.

There are currently three permitted monitoring wells at the STM Campus and no monitoring wells at the Flatirons Campus. Two permitted closed-loop geothermal systems that were

installed as part of research activities are in operation at the STM Campus: one at the Solar Radiation Research Laboratory and one near the South Site Entrance Building.

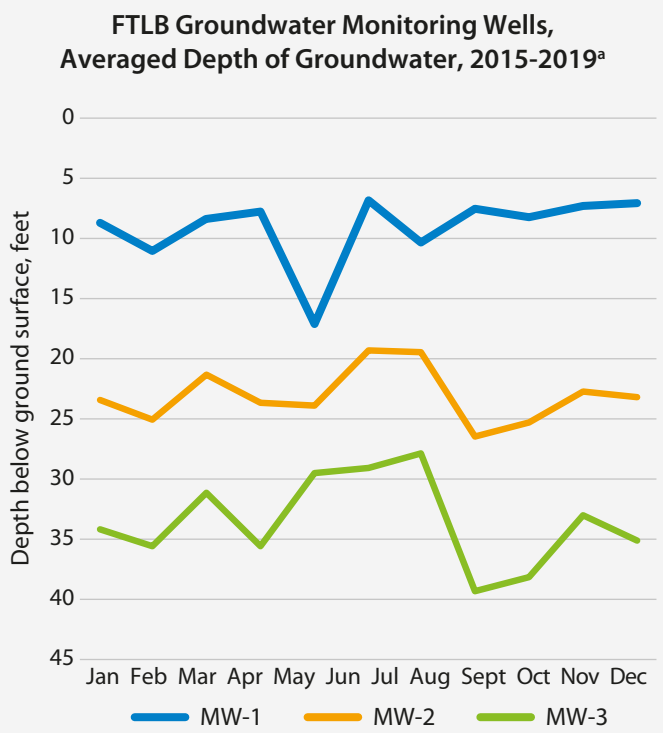
PFAS and Emerging Contaminants

Emerging contaminants of concern called per- and polyfluoroalkyl substances (PFAS) are a family of man-made chemicals that have been used since the 1940s. PFAS are used in consumer products and industrial processes to repel oil and water, resist heat, and reduce friction. Common applications include food packaging, household products (e.g., stain and water-resistant carpets and fabrics), nonstick products, waxes, chrome plating, electronics manufacturing, and fire-fighting foam. Though many PFAS chemicals are no longer manufactured in the United States, they persist in the environment and have been detected in soil, groundwater, and drinking water supplies, prompting the federal government to begin developing PFAS standards and regulation. The State of Colorado has developed an action plan to minimize further PFAS contamination in the environment and subsequent risks to state residents. To date, the State of Colorado has surveyed all fire departments in the state to characterize the use of fire-fighting foams that contain PFAS.

During an inventory of all on-site fire-suppression systems, NREL identified one 500-gallon system which contains a 3% PFAS solution at the STM Campus. The fire-suppression system was evaluated and it was determined that if the system was activated, the PFAS foam would be contained within the building and there would be little possibility of a release to the environment. Replacing the system with a non-PFAS product would require replacement of the tank and associated infrastructure; this project has been added to a list of projects for future funding.

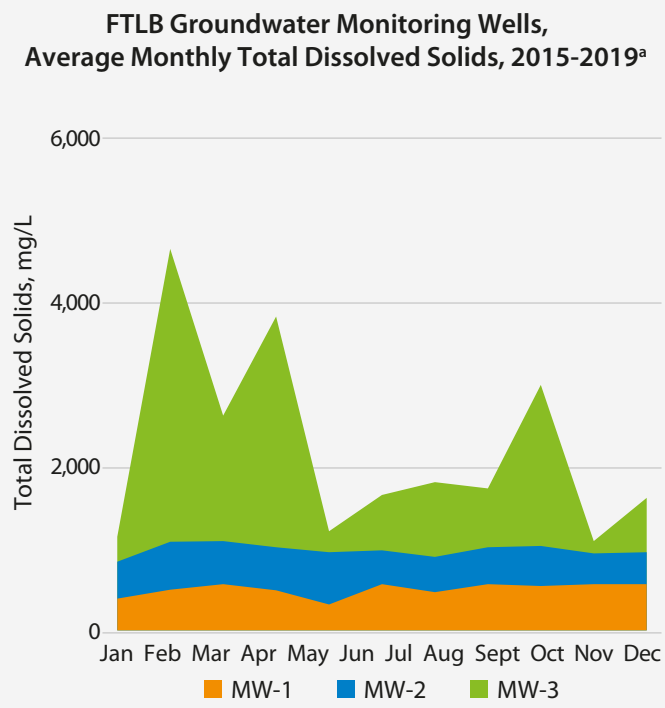
2019 Accomplishments and Highlights

- Collected and monitored groundwater level data for select water quality parameters in three groundwater wells north of the Field Test Laboratory Building (FTLB), with the goal of better understanding the cause of saturated soil conditions that have resulted in seepage into the building's north façade. Design and construction of improvements to direct surface flows away from the building are in progress. Monitoring of the wells will temporarily remain in place until the drainage is corrected. Monitoring data are presented in Figures 5, Figure 6, and Table 5.



[a] Groundwater level data measured in monitoring wells MW-1, MW-2, and MW-3 are shown as being averaged on a monthly basis over the period of data collection. No data were collected in August.

Figure 5. FTLB groundwater monitoring well data, 2015–2019: average groundwater levels[a]



[a] Total dissolved solids results obtained from samples collected from monitoring wells MW-1, MW-2, and MW-3 are shown as being averaged on a monthly basis over the period of data collection. No data were collected in August.

Figure 6. FTLB groundwater monitoring well data, 2015–2019: average total dissolved solids[a]

Table 5. FTLB Groundwater Monitoring Well Data, 2015–2019: Average pH[a]

Well ID	JAN	FEB	MAR	APR	MAY	JUN	AUG[b]	JUL	SEP	OCT	NOV	DEC
MW-1	7.6	8.2	8.7	8.1	8.0	7.85	—	8.1	7.9	7.4	7.3	7.7
MW-2	7.6	8.1	7.9	7.8	7.9	8.4	—	5.2	7.8	7.6	7.3	7.7
MW-3	8.2	8.0	8.1	7.5	8.0	8.6	—	5.0	8.2	7.3	7.9	7.6

[a] pH values of groundwater measured in monitoring wells MW-1, MW-2, and MW-3 are shown as being averaged on a monthly basis over the period of data collection.

[b] No data were collected in August.

Significant progress was made in 2019 to stabilize the eroding hillside adjacent to the Field Test Laboratory Building (FTLB) at the STM Campus. *Photo by Werner Slocum, NREL 61696*

6.3 Surface Water

Through its surface water program, NREL seeks to protect the quality of nearby receiving waters into which the STM Campus and the Flatirons Campus drain. These receiving waters include Lena Gulch at the STM Campus and Coal Creek and Rock Creek at the Flatirons Campus. Sediment, debris, and chemicals transported to these water bodies via stormwater runoff can harm or kill fish and other wildlife either directly or by destroying aquatic and riparian habitat. High volumes of sediment can result in stream bank erosion and clogging of waterways.

Water quality protection is accomplished through compliance with federal and state stormwater permitting requirements, management of stormwater runoff flowing across active construction sites, inclusion of project design elements that promote infiltration and detention of stormwater, and management of NREL grounds to minimize erosion and support infiltration.

In December of 2018, EPA Region 8 issued a Municipal Separate Storm Sewer System (MS4) permit to DOE for the STM Campus. This permit requires development and implementation of programs to reduce the discharge of pollutants in stormwater runoff from the site to the maximum extent practicable, thus protecting the water quality in Lena Gulch, the water body to which runoff from the site flows. The programs must include the following elements, termed "minimum control measures":

- Public education and outreach
- Public involvement
- Illicit discharge detection and elimination
- Construction site runoff
- Post-construction runoff
- Good housekeeping.

Program development must be complete by the end of the first five-year permit term. The programs will be implemented during subsequent permit terms.

Surface water is conveyed through many drainageways on the STM Campus, including this grassy swale located north of the Research Support Facility (RSF). *Photo by Brenna Birt, NREL 60727*

2019 Accomplishments and Highlights

- Continued stabilizing the hillside adjacent to the Field Test Laboratory Building. The building was first damaged by a water line break and further impaired by the erosive effects of the September 2013 flood event. Completion of the project, which includes installing retaining walls, installing a sidewalk, and stabilizing vegetation is anticipated to be completed in 2020.
- Implemented control plans for erosion and sediment on several small construction projects (less than one acre [0.4 hectare]) at the STM Campus helped prevent sediment deposits to nearby surface drainages and downstream waters.
- Began development on several of the MS4 permit programs intended to reduce the discharge of pollutants in stormwater runoff from the STM Campus. Specific accomplishments during 2019 included:
  - Established an MS4 Permit team to guide program development and implementation.
  - Developed a checklist to ensure environmental considerations, including stormwater protection, are properly addressed in new project design reviews. A checklist was also developed to guide construction site evaluations for comprehensive stormwater management.
  - Developed fact sheets that contractors and NREL staff can use to identify stormwater permitting and erosion control requirements on construction sites.
  - Completed a survey of all STM Campus stormwater outfalls during dry weather conditions to identify whether non-stormwater flows were observed. No dry weather flows were observed.
  - Investigated deicing materials, used for ice and snow removal operations, to identify those that balance safety and environmental concerns.
  - Updated mapping of the STM Campus stormwater infrastructure.

6.4 Wastewater

Untreated or poorly treated wastewater can contaminate surface and groundwater used for drinking water, irrigation, industrial, commercial, and recreational purposes. Most wastewater from the STM Campus and Denver West Office Park facilities flows into the Pleasant View Water and Sanitation District's (Pleasant View) system, and ultimately to the Metropolitan Wastewater Reclamation District's (Metro District) central treatment plant. Wastewater from the Renewable Fuels and Lubricants Research Laboratory also flows to the Metro District's treatment plant.

NREL's primary nondomestic wastewater discharge is generated at the STM Campus' IBRF, where research related to the production of bio-based products and fuels is conducted. Acids and bases are used in pilot-scale processes for converting cellulosic biomass into various fuels and chemicals. The pH of the effluent from these processes is adjusted to fall within the target pH range of 5–11 before being discharged into the sanitary sewer system. The Metro District and Pleasant View system managers periodically tour the facility and review operational controls.

For facilities that lack sanitary service, three small septic systems are in place, each consisting of a tank and a leach field: one is at the South Table Mountain mesa-top Solar Radiation Research Laboratory and two are on the Flatirons Campus. A preventative maintenance and inspection program is in place to confirm proper system function.

2019 Accomplishments and Highlights

- Completed the design for a new on-site wastewater treatment system for the Flatirons Campus. It will replace the existing system, which was installed in 1994 and designed for a much smaller site population.

A waste neutralization system used to treat wastewater discharge from a solar cell etching research tool in the Science and Technology Facility (S&TF) at the STM Campus. *Photo by Werner Slocum, NREL 55938*

7 HAZARDOUS MATERIALS AND HAZARDOUS WASTE MANAGEMENT

Responsible acquisition, use, and disposal of materials and waste are critical to meeting regulatory compliance, preventing pollution, and caring for the environment. NREL seeks to purchase materials that are sourced responsibly, contain recycled content, and have low toxicity in order to reduce the environmental impact of its waste streams.

Hazardous materials used on-site are thoughtfully controlled with internal procedures designed to limit health and environmental risks. Waste is carefully managed and disposed of through fully permitted facilities. Areas of focus for the laboratory include:

- Hazardous materials management
- Hazardous waste management
- Aboveground storage tank management
- Spill prevention and response
- Radiological materials and waste management.

Additional information about program management for each of these five areas of focus can be found in Appendix A.

2019 Accomplishments and Highlights

- Added new members to the Chemical Response Team and provided training in chemical response operations in accordance with emergency preparedness requirements. Additionally, spill response equipment resources were increased to provide effective spill response operations.
- The Chemical Response Team conducted operational drills and joint exercises internally and with external response organizations. The exercises were designed to train and strengthen response capabilities for potential incidents involving hazardous materials.

7.1 Hazardous Materials Management

Various chemicals and materials, some of which are hazardous, are used in research and maintenance activities at NREL facilities. Hazardous materials are stored, used, and managed in a manner that is protective of laboratory personnel, the public, and the environment. A hazardous materials management program is in place to guide and track the acquisition, use, and disposal of hazardous materials; doing so accomplishes environmental protection through compliance with state and federal requirements.

On October 6, at the Science and Technology Facility (S&TF), a drum of 93% concentrated sulfuric acid breached its first and secondary containers to release approximately 30 gallons (114 L) onto the second floor of the S&TF. The release of acid resulted in damage to equipment on the second floor and facility utility systems on the first floor. As a result, NREL deployed its internal Chemical Response Team to respond to the release and to prevent further propagation. Once the release was controlled, clean-up of acid and repair of utilities commenced. There was no release to the environment, and the event was not reportable to the State of Colorado or the EPA. A DOE investigation team determined the root cause to be the result of component failures and a secondary containment engineering control failure. Corrective actions are in development.

Table 6 summarizes the Emergency Planning and Community Right-to-Know Act (EPCRA) reporting requirements that were completed in 2019. The reporting requirements for each EPCRA section is defined in Section 4, Compliance Summary.

Table 6. 2019 EPCRA Reporting

EPCRA Section	Description of Reporting	Status
302	Planning Notification	Not required [a]
304	Extremely Hazardous Substance Release Notification	Not required [a]
311-312	Safety Data Sheet/ Chemical Inventory	Reported
313	Toxics Release Inventory Reporting	Not required [a]

[a] "Not required" indicates NREL was not required to report because it did not meet the threshold or it did not have an extremely hazardous substance release.

7.2 Hazardous Waste Management

Research and development activities and sitewide facility operations create a variety of waste streams, some of which contain toxic chemicals or metals. NREL typically disposes of or recycles the following categories of waste:

- Hazardous waste (as defined by environmental regulations)
- Nonhazardous waste such as low-toxicity chemicals, and containers and utensils contaminated with chemicals (does not include municipal solid waste, such as regular office trash)
- Universal waste such as mercury-manufactured articles and lamps, batteries, aerosol cans, used oil and electronic waste, including computers, monitors, and research instrumentation containing electronic circuitry.

Figure 7 provides a summary of the waste generated at NREL for the past five years.

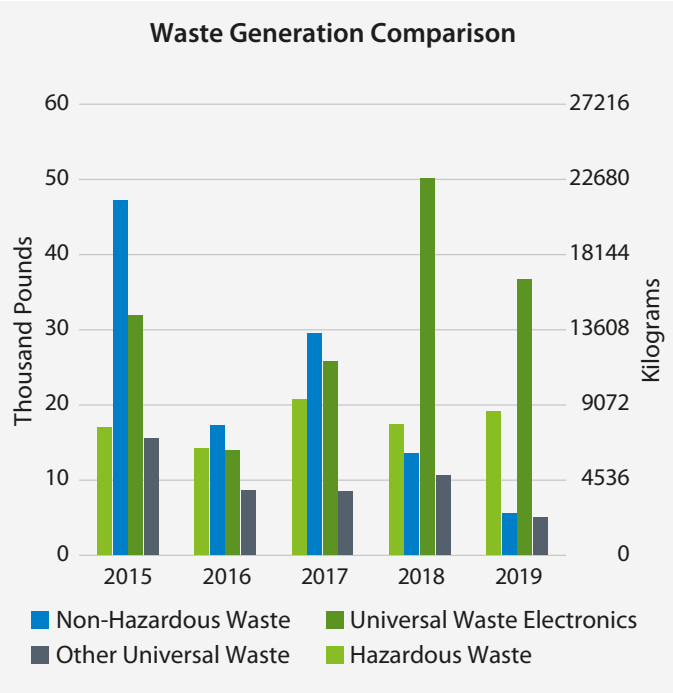


Figure 7. Comparison of four waste categories generated at NREL facilities by net weight

7.3 Aboveground Storage Tank Management

Appropriate tank management prevents or minimizes spills and leaks of fuels or oils that can contaminate soils, surface water, groundwater, and drinking water. Inspections such as monthly and annual visual, interstitial, and ullage log determination support the laboratory's commitments to environmental stewardship and pollution prevention.

Risk of underground soil and water contamination from storage tanks is reduced by using only aboveground storage tanks (ASTs). Unlike underground tanks, aboveground installations provide access for regular visual leak inspections and allow for less costly repair and cleanup.

NREL operates several petroleum-based ASTs, including:

- Five ASTs on the Flatirons Campus with a total capacity of 1,289 gallons (4,879 L)
- One AST at the NREL-occupied laboratory at the Denver West Office Park with a capacity of 500 gallons (1,893 L)
- Twenty ASTs on the STM Campus with a total capacity of 13,164 gallons (49,831 L).

ASTs are maintained using best management practices and according to applicable regulations. Five ASTs at the STM Campus were previously registered with the State of Colorado, but a state regulatory change now exempts ASTs at federal facilities from the registration requirement.

A 1,000-gallon gasoline aboveground storage tank (AST) on the STM Campus is maintained to refuel site support vehicles.
Photo by Dennis Schroeder, NREL 32151

7.4 Spill Prevention and Response

Spills of chemicals and petroleum products can result in contamination to soil, surface water, and groundwater, potentially causing damage to ecosystems, wildlife habitat, and human health. Comprehensive planning using spill prevention, control, and countermeasure (SPCC) plans can reduce spills and limit impacts to the environment when spills do occur.

SPCC plans have been developed and are in place for the STM Campus, the Flatirons Campus, and the Renewable Fuels and Lubricants Research Laboratory. As the total amount of petroleum stored at the Denver West Office Park is less than 1,320 gallons (4,997 L), and there is no petroleum at the Golden Warehouse, SPCC plans are not required at those locations.

NREL spill reporting and response policy requires staff to internally report all spills, regardless of the size of a spill. The purpose of this policy is to provide better historical spill information, identify locations where spills may occur more frequently, and promote a higher awareness of spill prevention importance. The number of spills and the quantity of spilled petroleum varies from year to year. The amount of oil spilled in 2019 was greater than in 2018, although there were fewer events in 2019 than in 2018. NREL continues to focus on a downward trend in spilled petroleum quantity and events.

2019 Accomplishments and Highlights

- Updated the laboratory's petroleum-containing equipment inventory.
- Inspected, restocked, and obtained materials to create additional spill kits for deployment at the STM Campus and Flatirons Campus.
- Responded to eight spills in 2019, including seven at the STM Campus and one at the Flatirons Campus. A total of approximately 37 gallons (140.1 L) of petroleum was spilled from these eight events, for an average of about 4 gallons (15.1 L) per spill. No spills were reportable to either EPA or the State of Colorado, and all spills were cleaned promptly, regardless of size.
- Provided annual SPCC training to 54 staff members. All staff responsible for operating or maintaining fuel- and oil-filled equipment are required to attend annual SPCC training. Online registration for training was made available for 2019, and six training events were scheduled at different locations to increase access to the training.

One of the many spill kits ready for deployment at the STM Campus.
Photo by Werner Slocum, NREL 56081

7.5 Radiological Materials and Waste Management

The laboratory currently uses a small amount of depleted uranyl acetate in electron microscopy staining. Several sealed sources are also present in analytical and process equipment, check sources, and emergency exit signs. Unlike many DOE facilities, NREL does not have legacy radiological contamination issues associated with past nuclear weapons production or research.

In 2017, NREL determined that research techniques that used select low-level radiological isotopes as biological tracers were no longer needed. As a result, in 2018, the designated laboratory space where those activities occurred was decommissioned and remediated before being returned to use for non-radiological experiments. All laboratory items (e.g., personal protective equipment, glassware, isotopic standards, chemical fume hoods, laboratory benchtops, and cabinets) removed during remediation remain on-site as preparations for final off-site shipment and disposal, in accordance with applicable state, federal, and DOE requirements, are completed.

Table 7 summarizes total activity on-site and the estimated effective dose equivalent to a member of the public for the past five years.

Equipment and Real Property Clearance

DOE orders identify the requirements that must be followed when releasing any potentially radiologically contaminated equipment or real property (i.e., land, buildings) to another DOE national laboratory, collaborating agency, or outside entity. These requirements detail the measurable radiological levels that must be verified and documented in order to comply with DOE authorized limits. Furthermore, internal procedures prohibit the disposition of equipment unless it has been decontaminated to background levels. In CY 2019 no equipment or real property was either requested, or authorized, for clearance to be released for reuse or disposal.

What is *"Effective Dose Equivalent"*?

To understand effective dose equivalent, dose and dose equivalent must first be defined:

- **Dose:** a generic term to describe the amount of radiation a person receives
- **Dose Equivalent:** a measure of the biological risk of the energy that the radiation deposited in tissue, which depends on the type of radiation and the tissues exposed; the units of dose equivalent are called rems, and a thousandth of a rem is called a millirem, which is abbreviated as mrem
- **Effective Dose Equivalent:** the total of the dose equivalent to the organ or tissue multiplied by weighting factors applicable to each of the body organs or tissues that are exposed to radiation

An average person in the United States receives about 310 mrem each year from natural sources and an additional 310 mrem from medical procedures and consumer products.

Table 7. Total Activity and Effective Dose Equivalent[a]

Calendar Year	2015	2016	2017	2018	2019
Total activity (mCi)[b]	3.88	3.88	3.88	3.88	3.88
Effective dose equivalent (mrem/yr)	0.036	0.038	0.045	0.037	0.037

[a] The allowable effective dose equivalent limit for each year is 10 mrem.

[b] Millicurie is abbreviated mCi.

A view from Rocky Flats National Wildlife Refuge with the Flatirons Campus in the background. *Photo by Tom Ryon, NREL 24474*

8 NATIONAL ENVIRONMENTAL POLICY ACT

The National Environmental Policy Act of 1969 (NEPA) is a federal law that serves as the national charter for protection of the environment, including natural, social, and economic impacts. NEPA requires the federal government to evaluate and understand the potential environmental impacts of a proposed action before resources—such as federal funds, properties, facilities, employees, and equipment— are committed. NEPA mandates that federal agencies weigh the potential for environmental impacts equally among all factors when making decisions about proposed actions.

In compliance with NEPA, potential environmental impacts from a wide range of activities conducted by NREL staff at both on-site and off-site facilities are evaluated before authorizing funds or commencing work. The NEPA process represents an effective means for project managers, scientists, and engineers to understand the potential environmental impacts of proposed activities and identify actions to minimize impacts. Additional information about NREL's management of its NEPA program activities can be found in Appendix A.

2019 Accomplishments and Highlights

- Developed online NEPA training for staff who support NEPA evaluations, and a NEPA general awareness training for all interested staff. The trainings are designed to improve awareness of and compliance with the laboratory's NEPA process.
- Increased engagement with staff to raise understanding and awareness of NEPA requirements, developed answers to frequently asked NEPA questions, and enhanced NEPA information presented on NREL's intranet.
- Completed a NEPA program self-assessment, and identified and implemented program improvements.

9 NATURAL AND CULTURAL RESOURCES PROTECTION

Mule deer (*Odocoileus hemionus*) bucks line up along the north side of the Research Support Facility (RSF) to escape the summer heat. *Photo by Werner Slocum, NREL 58283*

Natural resources at the STM Campus and the Flatirons Campus are managed responsibly to ensure NREL's research needs are met while protecting native wildlife, vegetation, and cultural resources. Responsible management benefits not only the environment, but also NREL employees and the surrounding community. Management focuses on these key areas:

- Wildlife management
- Endangered species and species of concern
- Vegetation management
- Wetlands and floodplains
- Cultural resources.

Additional information about program management for these five areas can be found in Appendix A.

9.1 Wildlife Management

Given the laboratory's location just east of the foothills of the Front Range, wildlife is plentiful at both the STM Campus and the Flatirons Campus.

NREL promotes responsible management of wildlife and habitat through periodic formal surveys and reviews of impacts to wildlife when designing and implementing projects. At the STM Campus, the original wildlife survey of the property was completed in 1987 and an additional study of the conservation easement property was performed in 1999; subsequent surveys were completed on that property in 2005 and 2011. In 2017, the STM Campus was surveyed once again.

Mammals identified during the surveys of the STM Campus included mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), coyotes (*Canis latrans*), bobcat (*Lynx rufus*), striped skunks (*Mephitis mephitis*), cottontails (*Sylvilagus* spp.), and various smaller mammals. More than 80 species of birds have been recorded by the formal wildlife surveys and supplemental employee observations. At least seven raptor species have been recorded at or above the STM Campus, especially during spring migration. Two raptor species are residents at the site:

the American Kestrel (*Falco sparverius*) and the Red-tailed hawk (*Buteo jamaicensis*). Owls that occupy the STM Campus include the Great horned owl (*Bubo virginianus*) and Northern Pygmy-Owl (*Glaucidium gnoma*). Reptiles and amphibians also inhabit the STM Campus; most notably, the Woodhouse's toad (*Anaxyrus woodhousii*) breeds in ephemeral ponds on the STM conservation easement property.[5]

DOE prepared a biological characterization inventory in 1992 for the entire Rocky Flats Plant area, a former production site for nuclear weapons. The area includes the Flatirons Campus, which was part of the no-activity buffer zone of the Rocky Flats Plant at the time. Signs or tracks of bears and mountain lions were identified. Approximately 20 species of birds were sighted at or near the Flatirons Campus at that time.

Raptor surveys conducted at the Flatirons Campus in 1994 and 1995 identified seven raptor species on or in the vicinity of the campus. An avian survey was again completed in 2003 and updated in 2011.[6] A 2016 survey included mammals, reptiles, and amphibians with results duplicating the 2011 survey that showed that various mammals, including elk, mule deer, coyotes, cottontails, bobcats, several species of bats, deer mice (*Peromyscus maniculatus*), prairie voles (*Microtus ochrogaster*), and masked shrew (*Sorex cinereus*) continue to feed at and occupy the Flatirons Campus. Although seldom seen, Western (prairie) rattlesnakes (*Crotalus viridus*), bull snakes (*Pituophis catenifer*), racers, and several other reptiles are also known to occupy the Campus. Amphibians, including Boreal chorus frogs (*Pseudacris maculata*), Woodhouse's toad, and Northern leopard frog (*Lithobates pipiens*), occupy ephemeral wetlands at the Flatirons Campus.

Ultrasonic recording of bat calls was conducted at the Flatirons Campus from February to December. The recording device was located within a utility-scale turbine nacelle 262 feet (80 m) above the ground. Five bat species were verified as occurring within the study area: Hoary bats (*Lasiurus cinereus*), Silver-haired bats (*Lasionycteris noctivagans*), Eastern red bat (*Lasiurus borealis*), Big brown bat (*Eptesicus fuscus*), and Little brown myotis (*Myotis lucifugus*). Bats grouped by the frequency of their echolocation (i.e., low and high frequencies) are shown in Figure 8. Low frequency bats (Hoary bats, Silver-haired bats, and Big brown bats) tend to fly at higher altitudes, while high frequency bats (*Myotis* spp. and Eastern red bat) tend to fly at lower altitudes. The graph shows the seasonality of bat activity that peaks in August as young bats join adults in flight, and the number of calls decrease as Hoary bats and Silver-haired bats migrate to southern latitudes.

A total of 16 bats were found dead in August and September of 2019 under the three utility-scale turbines in operation on the Flatirons Campus, and 13 of these bats were found below one turbine. Twelve of the bats were identified as Hoary bats, two as Silver-haired bats, and two as Little brown bats. The laboratory continues to track bat mortality and identify operational practices to minimize them.

Complete lists of all wildlife species identified at both the STM Campus (Table C-1) and the Flatirons Campus (Table C-2) are found in Appendix C.

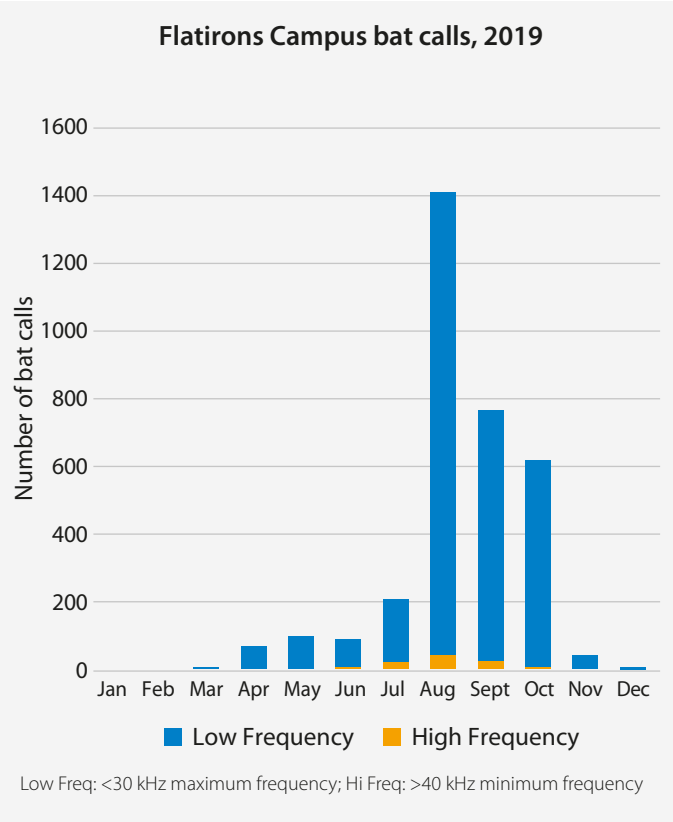


Figure 8. Results of 2019 Flatirons Campus bat calls by frequency

A common muskrat (*Ondatra zibethicus*) was observed on the STM Campus. The common muskrat is found in wetlands over a wide range of climates and habitats. *Photo by Eryn Lussier, NREL 60039*

5. Two Dot Consulting, LLC. 2017. *2017 Vegetation and Wildlife Surveys at the National Renewable Energy Laboratory, South Table Mountain*. Jefferson County, Colorado.
6. Tetra Tech EC, Inc. 2011. *Avian Monitoring and Mortality Report: National Wind Technology Center*. Jefferson County, Colorado.

2019 Accomplishments and Highlights

- Observed a common muskrat *(Ondatra zibethicus)* on the STM Campus near the detention basin in early November. This was the first recorded sighting of this mammal on either of NREL's campuses.
- Observed a yellow-bellied marmot *(Marmota flaviventris)* at the Flatirons Campus in August. Although they are typically seen at higher elevations, the Flatirons Campus is within the elevational range of marmots in Colorado. This was the first sighting of this mammal on either of NREL's campuses.
- Developed a Wildlife Response Operational Plan that explains roles, responsibilities, and appropriate responses for a variety of wildlife-related calls.
- Captured and tagged Prairie rattlesnakes *(Crotalus viridis)* with passive integrated transponders at South Table Mountain Park and inside the STM Campus boundary. The transponder tags are read and identified using a unique 10-digit alphanumeric code. Eleven rattlesnakes were tagged in 2018 and 2019, but none have been recaptured. One of the eleven was found dead.
- Provided training sessions to NREL staff on snake ecology and taxonomy to minimize injuries to snakes and to enhance safety awareness of responders during snake relocation activities. The training was conducted by a local consulting firm specializing in human-wildlife interactions.
- Hosted a series of wildlife talks at the NREL Education Center, including talks on attracting birds sustainably by an NREL wildlife biologist and a member of Wild Birds Unlimited, coyote awareness by a Jefferson County Visitor Service Ranger, and rattlesnake awareness by a member of Adaptation Environmental Services.
- Hosted two nature walks with NREL biologists for Earth Day.
- Observed Tree swallows *(Tachycineta bicolor)* and American Kestrels *(Falco sparvierus)* return to nest boxes at the STM Campus and successfully fledge young.
- Commented on the USFWS five-year listing review of the New Mexico Meadow Jumping Mouse *(Zapus hudsonius luteus)*. The five-year review is required by the Endangered Species Act to monitor listed species; it is used to see whether (1) the listing of the threatened or endangered species needs to change and (2) specific species have recovered and can be proposed for delisting.
- Provided nesting bird survey training to appropriate staff at both NREL campuses.

9.2 Endangered Species and Species of Concern

The federal Endangered Species Act (ESA) provides for the designation and protection of wildlife, fish, and plant species that are in danger of extinction and preserves the habitats on which these species depend. Compliance ensures the laboratory's actions do not adversely affect threatened, endangered, or candidate species that are listed under the ESA. NREL also complies with the Colorado Division of Parks and Wildlife restrictions related to endangered, threatened, and species of concern for Colorado, as well as the rare plant species listed under the Colorado Natural Heritage Program.

The USFWS, which administers the ESA, lists eight species that are threatened, endangered, or a candidate for listing that could potentially be found in Jefferson County or Boulder County. Of these species, two have the potential to occur at the STM Campus or the Flatirons Campus: the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) and the Ute ladies' tresses orchid (*Spiranthes diluvialis*). According to the USFWS's Information, Planning, and Consultation System database, an additional eight bird species listed as species of special concern, along with several other species on the State of Colorado's list of Species of Greatest Conservation Concern could also exist in Jefferson County or Boulder County.

In 2019, the Colorado Butterfly Plant (*Gaura neomexicana* spp. *coloradensis*) was removed from the Federal List of Endangered and Threatened Plants list as a result of its recovery. Efforts within Colorado and Wyoming have successfully reduced the threats to this species to the point where it is no longer likely to become endangered in the foreseeable future. The USFWS ruling about the Colorado Butterfly Plant, which became effective on December 5, 2019, impacts NREL in that surveys for this species is no longer required during baseline studies at either the STM Campus or the Flatirons Campus.

In 2017, a survey of the STM Campus did not detect any threatened species, endangered species, or species of concern. The 2016 the Flatirons Campus survey revealed three State of Colorado Species of Greatest Conservation Concern to be present: the Fringed myotis (*Myotis thysanodes*), Little brown myotis (*Myotis lucifugus*), and Northern leopard frog. Note that for a bird species to be counted as occupying the STM Campus or the Flatirons Campus, the bird could not simply be flying over the site but had to be stopping over or otherwise using habitat at the site, such as by nesting or foraging.

This Golden Eagle (*Aquila chrysaetos*) was brought by researchers to the Flatirons Campus, but they can be found at both NREL campuses. The Golden Eagle is a species of concern in Colorado and nationwide. *Photo by Dennis Schroeder, NREL 35733*

The USFWS has designated critical habitat associated with the federally endangered Preble's meadow jumping mouse within the upper reaches of Rock Creek, including a small area at the southeastern corner of the Flatirons Campus. This area may not be disturbed without prior coordination with the USFWS.

Five other species that occur in the Platte River watershed in Nebraska are listed by the USFWS as species that must be considered for Colorado and Wyoming projects that may deplete water supplies to the Platte River system. These include three birds (the Piping plover [*Charadrius melodus*], the Whooping crane [*Grus americana*], and the Least tern [*Sternula antillarum*]), a fish (the Pallid sturgeon [*Scaphirhynchus albus*]), and a plant (the Western prairie fringed orchid [*Platanthera praeclara*]). As part of the STM Campus and the Flatirons Campus NEPA environmental assessments conducted in 2014, DOE consulted with the USFWS for future activities that have the potential to deplete water in the Platte River system. In accordance with requirements agreed upon during the consultation, NREL monitors water use to ensure the established amounts are not exceeded. NREL's water use is reported to the USFWS annually.

9.3 Vegetation Management

Native plants have evolved over long periods of time in harmony with the local climate and surrounding soil, growing in association with microorganisms and resident wildlife to create diverse ecosystems. Through this evolution, native plants have developed natural defenses against pests and diseases specific to their locale. When non-native plants are introduced into an environment, they often overcome indigenous plants, attract new types of pests and diseases, and outcompete native plants for nutrients and water. They can also deprive wildlife of nutrients and shelter. Plants such as kochia (*Bassia scoparia*), Canada thistle (*Cirsium arvense*), Russian olive (*Elaeagnus angustifolia*), diffuse knapweed (*Centaurea diffusa*), dalmation toadflax (*Linaria vulgaris*), and myrtle spurge (*Euphorbia myrsinites*) are examples of non-native plants that can have destructive effects on natural habitats.

Vegetation management incorporates four main areas: native landscaping, weeds, wildfire risk, and imported plants and organisms.

Native Landscaping: Landscaped areas near NREL buildings and common areas are designed to incorporate features such as native plantings, xeriscape principles suited to arid climates, and infiltration of stormwater to provide water and nutrients to landscape plants and to recharge groundwater in the area. Adhering to such designs helps promote wildlife-friendly vegetation and reduces the introduction of non-native species and the pests and diseases that can accompany them. NREL actively manages the vegetation on its sites to maintain the native plant communities and manage wildfire risk.

Weed Management: Where non-native species exist, NREL uses an integrated weed management approach that incorporates various types of weed control methods, including mechanical practices (e.g., mowing or hand-pulling), cultural practices (e.g., reclamation of disturbed areas), prevention (e.g., limiting or eliminating driving off established roadways), biological practices (e.g., introducing state-approved insects and fungus that feed on specific weed species), and treatment using herbicides. For example, the use of multiple control strategies has been successful in significantly reducing populations of diffuse knapweed and Canada thistle. The weed control program maintains the flexibility needed to respond to changes in weed populations from year to year, and periodically assesses the effectiveness of the control methods it employs.

Comprehensive site-wide weed surveys and mapping are performed approximately every five years. Smaller areas of NREL's main sites are assessed annually. The noxious weed species, as defined on the State of Colorado's noxious weed list, that have been identified at the STM Campus and the Flatirons Campus are listed in Table 8.

Wildfire Risk Management: Part of managing native vegetation at NREL is finding a balance between preserving and manipulating the landscape to reduce wildfire risk. NREL has a fire management program which includes wildfire assessments, fire risk management, and identification of areas of wildland-urban interface. These areas are being managed to achieve and maintain defensible space around buildings and other infrastructure against wildland fires. Most of the fire management activities can be done in conjunction with other vegetation management activities, such as weed control. Annual assessments of defensible space are conducted for the STM Campus and the Flatirons Campus.

Imported Plant and Organism Permits: An additional component of NREL's vegetation management program relates to the periodic use of certain animal and plant materials in research at the laboratory. Certain organisms and plants that are obtained from other states or from outside the United States are controlled by the Animal and Plant Health Inspection Service (APHIS). These might include the use of certain pathogenic organisms used in biomaterials research or plants such as sugarcane bagasse and other scrap agricultural products that are tested for their value in biofuels and biomaterial production. By the end of 2019, NREL held two active APHIS permits for microorganisms imported to the STM Campus from within the United States and from Japan. Two additional permits that were obtained for imported plant materials were allowed to expire. A permit obtained in 2016 for research related to several organisms imported from Puerto Rico and the U.S. Virgin Islands was terminated following a site visit by U.S. Department of Agriculture APHIS personnel who verified that all permit requirements related to destruction of the permitted organisms had been properly completed.

Indian Paintbrush (*Castilleja* spp.) grows in native grasslands around the STM Campus. *Photo by Werner Slocum, NREL 56737*

Table 8. Noxious Weed Species Identified at the STM Campus and the Flatirons Campus[a]

Noxious Weed Class	Species Present at STM Campus (Common name [Scientific name])	Species Present at Flatirons Campus (Common name [Scientific name])
Class A[b]	Myrtle spurge (*Euphorbia mysinites*)	None
Class B[c]	Canada thistle (*Cirsium arvense*)	Bull thistle (*Cirsium vulgare*)
	Common teasel (*Dipsacus fullonum*)	Canada thistle (*Cirsium arvense*)
	Dalmation toadflax – broad-leaved (*Linaria dalmatica*)	Common teasel (*Dipsacus fullonum*)
	Diffuse knapweed (*Centaurea diffusa*)	Dalmation toadflax – broad-leaved (*Linaria dalmatica*)
	Hoary cress (*Cardaria draba*)	Diffuse knapweed (*Centaurea diffusa*)
	Houndstongue (*Cynoglossum officinale*)	Hoary cress (*Cardaria draba*)
	Leafy spurge (*Euphorbia esula*)	Leafy spurge (*Euphorbia esula*)
	Musk thistle (*Carduus nutans*)	Moth mullein (*Verbascum blattaria*)
	Russian olive (*Elaeagnus angustifolia*)	Musk thistle (*Carduus nutans*)
	Scotch thistle (*Onopordum acanthium*)	Sulfur cinquefoil (*Potentilla recta*)
Class C[d]	Downy brome, cheatgrass (*Bromus tectorum*)	Downy brome, cheatgrass (*Bromus tectorum*)
	Field bindweed (*Convolvulus arvensis*)	Field bindweed (*Convolvulus arvensis*)
	Common mullein (*Verbascum thapsus*)	Chicory (*Cichorium intybus*)
		Common mullein (*Verbascum thapsus*)
		Common St. John's wort (*Hypericum perforatum*)

[a] Species identified reflect the findings of site-wide weed surveys performed in 2011 at the STM Campus and in 2016 at the Flatirons Campus

[b] Identified by the State of Colorado for eradication

[c] Identified by the State of Colorado to stop the spread

[d] Identified by the State of Colorado to more effectively manage on private and public lands through education, research, and biological control resources

2019 Accomplishments and Highlights

- Conducted a quarterly review and coordination meetings to evaluate the success of seasonal herbicide applications and revegetation efforts.
- Performed annual herbicide spraying to control diffuse knapweed and sulfur cinquefoil *(Potentilla recta)* at the Flatirons Campus, and Canada thistle, hound's tongue *(Cynoglossum officinale)*, and myrtle spurge at the STM Campus.
- Discovered leafy spurge growing in a small area within the Flatirons Campus. The area was quickly treated and then resurveyed two months later, when the surviving leafy spurge were sprayed again. The treated areas will be surveyed in 2020.
- Maintained professional relationships with various departments within Jefferson County and Colorado Parks and Wildlife. As a result, NREL received a notification from the Jefferson County Noxious Weed Coordinator that a small patch of leafy spurge was discovered by a hiker on the DOE South Table Mountain conservation easement property. Additionally, Jefferson County Open Space provided the location of a myrtle spurge *(Euphorbia myrsinites)* patch on the STM Campus that was previously unknown; those areas were treated and will be surveyed again in 2020.
- Created fire buffers by mowing or maintaining gravel skirts around all structures and equipment at the Flatirons Campus. These areas were revisited in mid-summer and many areas were mowed a second time to lessen fire risk.
- Mowed or hand-cut overgrown rabbitbrush within two feet of all sidewalks and areas. Limited herbicide applications were also used in areas near utility boxes. Although rabbitbrush is not a noxious weed, it has proliferated at the STM Campus, changing the character of the grassland habitat and increasing the severity of a wildland fire, should one occur. Rabbitbrush provides considerable wildlife habitat, including foraging habitat for pollinators throughout the growing season and shelter habitat for a variety of vertebrate species; as such, it is managed to balance limiting growth and providing important habitat within the site.
- Reviewed tree and shrub types for the Flatirons Campus Landscape Project, which included assessing plants for wildlife and pollinator habitat potential, wildfire risk, and maintenance requirements.

9.4 Wetlands and Floodplains

Wetlands are lands that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetland areas typically take the form of swamps, marshes, bogs, and groundwater seeps, and they are frequently located within or adjacent to a floodplain. Floodplains are land areas adjacent to rivers and streams that are subject to recurring inundation.

Both wetlands and floodplains play a key role in providing floodwater storage, reducing flood flow rate, filtering floodwater, and recharging groundwater. The resulting enriched floodplain soils promote the growth of wetland and riparian vegetation that provides habitat for a rich diversity of terrestrial and aquatic plants and animals.

Floodplains vary in extent from those that contain the more frequent low-volume rain event flows to widths that have the capacity to contain a 100-year flood event and greater. In general, stream channels at NREL sites are better characterized by the former description. There are no 100-year floodplains defined by Jefferson County or the Federal Emergency Management Agency on NREL sites.

Table 9. Wetland Types and Acreages at the STM Campus and the Flatirons Campus

Wetland Type[a]	STM Campus (acres [hectares])	Flatirons Campus (acres [hectares])
Headwaters	0.0 (0.0)	2.0 (0.9)
Palustrine Emergent	1.3 (0.6)	3.6 (1.4)
Seasonal Ponds	0.6 (0.2)	0.6 (0.2)
Wet Meadows	0.3 (0.1)	0.0 (0.0)
Total	**2.2 (0.9)**	**6.2 (2.5)**

[a] Palustrine emergent wetland areas have been surveyed and meet all federal wetland criteria. Other wetlands listed were identified by vegetation type only.

Table 9 lists the types and acreage of wetlands at the STM Campus and the Flatirons Campus that have been identified to date. See Appendix D, Plant Communities at the STM Campus and the Flatirons Campus, for a detailed description of the types and locations of these wetlands.

NREL strives to preserve the important natural functions of its wetlands and floodplains, regardless of size or extent, to protect the physical, biological, and chemical integrity of receiving waters and riparian areas on and adjacent to the STM Campus and the Flatirons Campus.

2019 Accomplishments and Highlights

- Conducted a wetland delineation of the Middle Drainage area within the STM Campus. Based on the field investigation for that effort, approximately 1.70 acres (0.69 hectares) of non-jurisdictional wetlands were identified within the study area. This information will be submitted to the U.S. Army Corps of Engineers in 2020 for a jurisdictional determination, and will be used to inform future planning for development of the STM Campus.

9.5 Cultural Resources

Cultural resources are defined as any prehistoric or historic district, site, building, structure, or object considered important to a culture, subculture, or community for scientific, traditional, religious, or other reasons.

Cultural resources can be divided into three major categories:

- Prehistoric and historic archaeological resources
- Architectural resources
- Traditional cultural resources.

Much of the land currently occupied by the STM Campus was once part of Camp George West, a military facility operated by the Colorado National Guard from 1903 through the early 1930s. It was later leased to the federal government for military training purposes. Therefore, several formal surveys of historic and cultural resources have been performed on the STM Campus. Three historical resources have been identified as significant cultural resources that should be preserved under the Archeological and Historic Preservation Act of 1974. These three resources, which were constructed in the 1930s and early 1940s during the Works Progress Administration era, are located at the STM Campus. They include:

- An open-air amphitheater
- A stone bridge spanning a natural drainage channel adjacent to the amphitheater
- A stone and concrete ammunition "igloo" below the amphitheater.

The Colorado Amphitheater, built in 1935, is a natural stone amphitheater that remains on the side of South Table Mountain, north of the STM Campus. The structure is listed on the National Register of Historic Places. *Photo by Werner Slocum, NREL 56807*

Through NREL's efforts, these structures have been added to the National Register of Historic Places, with the amphitheater and stone footbridge being listed together as a single resource. Additionally, a portion of the STM Campus south of Denver West Parkway lies within the 98-acre Camp George West Historic District.

A formal survey of the Flatirons Campus conducted in 1995[7] did not identify any significant historical or archeological resources.

7. Labat-Anderson, Inc. 1995. *Archaeological Assessment of the National Wind Technology Center*. January 1995.

10 CONSERVATION LANDS

The view west from the conservation easement property at the STM Campus. *Photo by Kurt Schlomberg, NREL 50038*

In 1999, DOE granted Jefferson County a conservation easement of 177 acres (72 hectares) at the STM Campus (see Figure 9).

A baseline inventory of the property was prepared in 1999 to document the condition of the easement property and to assess its conservation value.[8] The baseline inventory includes descriptions of the geographical setting and adjacent property owners, access and use of the property by the public, and the existing environmental conditions of the property (including geology, hydrology, vegetation, wildlife, and cultural resources). Vegetation within the easement area includes grasslands interspersed with shrubland communities and trees, primarily in the drainages. Several seeps also occur throughout the area.

The easement helps preserve the natural character of the property, including its visual, biological, and recreational resources. The goals of the easement are to:

- Retain, preserve, and protect natural, scenic, ecological, and historic resources
- Protect the ecosystem and provide sustainable habitat for diverse vegetation and wildlife
- Ensure the scenic and biological integration with adjoining open space land
- Prevent further industrial, commercial, or residential development
- Preserve the conservation easement property as open space.

Local policies established by Jefferson County, the City of Golden, and the City of Lakewood reflect community sensitivity about the visual qualities provided by natural resources in the area around the STM Campus. Specifically, the Jefferson County General Land Use Plan characterizes North Table Mountain and South Table Mountain as "unique

8. U.S. Department of Energy. Golden Field Office. 1999. *National Renewable Energy Laboratory (NREL) Site Conservation Easement Baseline Inventory.* Golden, Colorado.

landscapes" and states that "maintaining landscapes that have a unique visual quality" is key to maintaining the quality of life in Jefferson County.

Jefferson County Open Space maintains formal trails on the conservation easement property. Two trails cross the easement, connecting Denver West Parkway (near the STM Campus east entrance) to the trails on the mesa top. NREL staff, DOE staff, and the public use these trails frequently.

Each year, at least one visual inspection of the conservation easement property is conducted to identify management activities needed to address erosion, weed management, trail conditions, or other issues that may exist.

2019 Accomplishments and Highlights

- Inspected the conservation easement property in the summer; two areas for noxious weed control were identified and added to annual weed management planning. An inventory of Siberian elms was started during the inspection and are being considered for removal. Russian olives, which have been managed over the past several years, have largely been eliminated.
- Applied herbicides in grassland areas within the STM Campus conservation easement. The herbicides targeted leafy spurge and cheatgrass, both Colorado Noxious Weed List B species.
- Hosted Jefferson County Open Space for its annual assessment of the conservation easement property. The resulting Conservation Easement Annual Monitoring Report noted that noxious weeds are present within the property, including diffuse knapweed *(Centaurea diffusa)*, dalmatian toadflax *(Linaria dalmatica)*, and common mullein *(Verbascum thapsus)*. NREL has previously identified these noxious weeds on the easement property and has been working, and will continue to work, to control them.

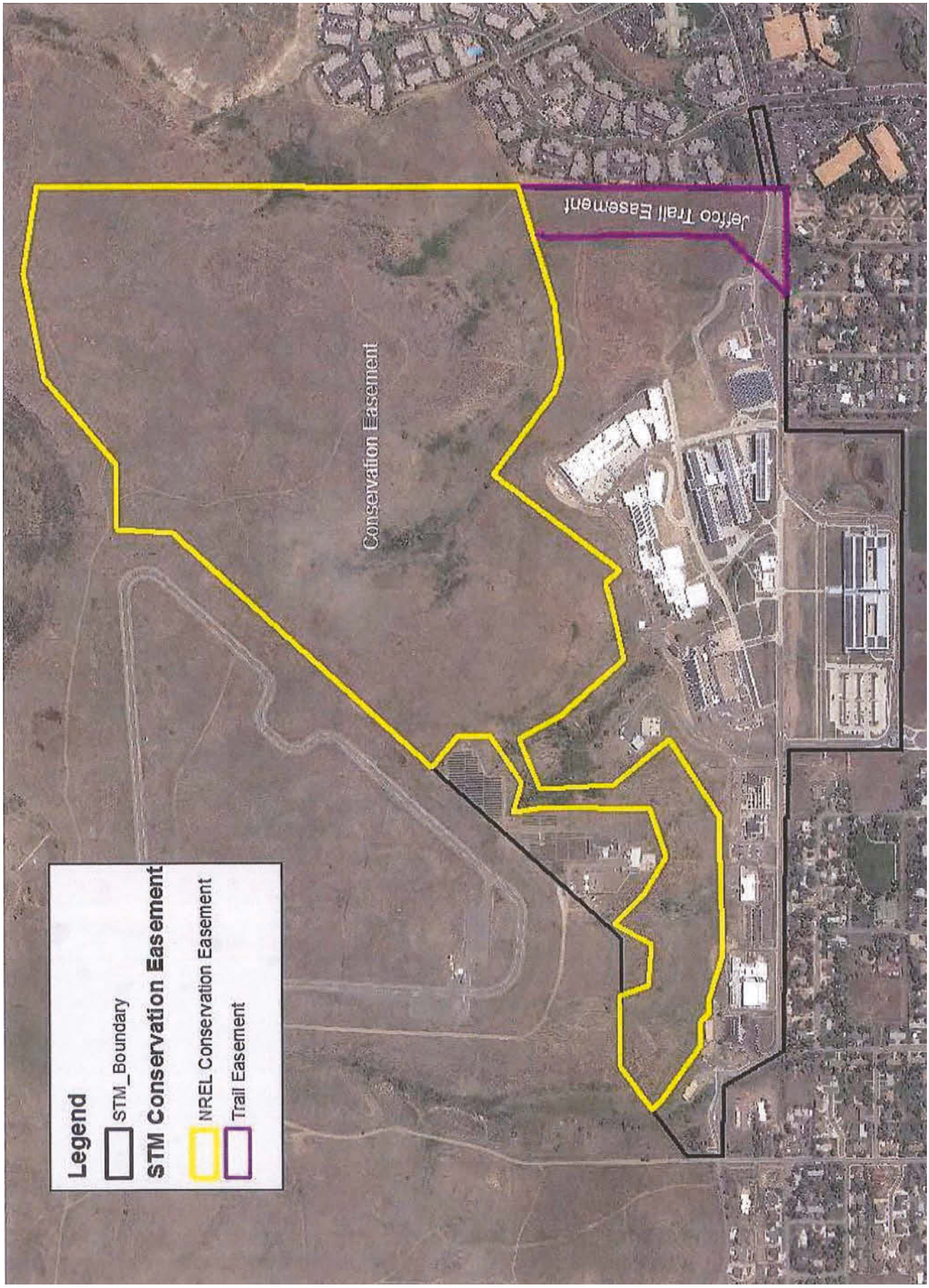


Figure 9. Conservation Easement at the STM Campus

Twin Mule deer (*Odocoileus hemionus*) fawns outside the STM Campus Cafeteria. *Photo by Werner Slocum, NREL 51583*

APPENDIX A.

PROGRAM MANAGEMENT DESCRIPTIONS

Environmental Management Systems

NREL's EMS is implemented via the following:

- Establishment of environmental policies and programs that guide site operations (including research and site development) and maintenance; these policies and programs undergo regular reviews and updates
- Annual identification of federal laws and regulations, state and local requirements, executive and DOE orders, and standards to address environmental hazards
- Annual identification of environmental stewardship goals and actions and regular planning to achieve them
- Verification of worker competence with regard to environmental requirements through various training programs
- Communication with surrounding communities and regional agencies to collaborate on environmental goals
- Maintenance of accurate document records and controls
- Monitoring and performing corrective actions
- Conducting internal and external program assessments
- Maintenance of adherence to the ISO 14001 standard.

Pollution Prevention

The laboratory prevents pollution by implementing environmental and sustainability programs that cover waste management and minimization, hazard identification and control, energy conservation, sustainable purchasing, sustainable transportation, water conservation, and sustainable building operation and maintenance.

Sustainability

The sustainability program addresses multiple areas of sustainability, including GHG management and reduction, high-performance sustainable buildings, energy efficiency, renewable energy, water management, fleet management,

waste management and reduction, sustainable procurement processes, climate change resiliency planning, community engagement, and changes in employee culture.

The program addresses sustainability using an integrated and holistic approach. For example, NREL is committed to the design, operation, and maintenance of high-performance sustainable buildings by employing building design and operation strategies that promote optimal performance and maximize life-cycle asset value. These operational strategies can also support NREL's mission, which includes developing renewable energy projects, reducing overall laboratory energy and water usage, and improving sustainable work habits of employees. The sustainability program is able to leverage a variety of expertise and experience to integrate sustainable operations throughout the laboratory to improve performance and resilience.

In addition, the sustainability program works closely with researchers throughout the laboratory to continually develop partnerships that support NREL's mission while improving facility operations. NREL serves as both a living model of sustainability and a place to develop new clean energy ideas, technologies, and practices.

Resilience

NREL's resilience program is designed to anticipate, prepare for, and adapt to changing conditions and to withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions. To accomplish these objectives, a list of actions has been developed to manage short- and long-term risks. Each year, the laboratory works to make progress on these action items.

Air Quality Protection

The objectives of NREL's air quality program consist of minimizing air emissions related both to research and employee commuting activities, monitoring emissions from larger on-site sources, and meeting all required emission standards and permitting requirements. Specific management practices relative to the types of air pollutants emitted are described below.

Criteria Pollutants and Hazardous Air Pollutants Permitting

The laboratory maintains an air-emission inventory to track potential emissions and identify whether future notification and permitting could be required for a particular facility or activity. Projected emissions for new sources are evaluated and air-emission reporting and permitting are performed as required.

The laboratory maintains several air permits issued by the State of Colorado for "minor" sources (such as standby electrical generators and pollution control systems) that are subject to minimal permit and compliance requirements.

On December 26, 2019, EPA redesignated the Denver metropolitan ozone nonattainment area from "moderate" to "serious." The new designation redefined a major source of NO_x or VOC emissions as 100 U.S. tons (90.7 MT) per year rather than 50 U.S. tons (45.4 MT) per year. The STM Campus is now considered a major source and a Title V operating permit is required.

The laboratory has a fugitive particulate emissions permit in place for the STM Campus because of construction activity over the last several years. The permit requires certain actions during earth-moving activities to minimize associated particulate emissions. To further minimize the generation of airborne particulates, NREL uses a non-sand deicer to maintain roadways. Avoiding the use of sand minimizes potential fugitive particulate emissions from snow removal operations, thus contributing to improved air quality for neighbors and meeting the Denver metro region requirement for controlling particulate matter emissions from on-site vehicle traffic.

Greenhouse Gas Emissions Tracking and Permitting

Permitting and reporting of GHGs are not currently required for NREL facilities as emissions are below EPA permitting and reporting thresholds. EPA requires that CO_2e GHG emissions from any source that is greater than 27,500 U.S. tons (25,000 MT) per year be reported to EPA annually. EPA also requires a major source of criteria pollutants also include CO_2e emissions in the major source permit if CO_2e emissions exceed 75,000 U.S. tons (68,000 MT) per year. The STM Campus is a major source of criteria pollutants, while all other NREL facilities are considered minor sources. CO_2e emissions for all facilities are less than both of the above-mentioned limits.

Refrigerant Management

The EPA and the State of Colorado regulate refrigerants to reduce emission of these compounds to the atmosphere. The NREL refrigerant management program is intended to achieve that goal.

Management of refrigerants, including ODS, is accomplished by maintaining a detailed inventory of refrigerants and appliances containing more than one pound of any refrigerant. The inventory identifies equipment that is subject to end-of-life disposal requirements, and larger appliances that are subject to detailed repair and documentation standards. NREL's management of refrigerants includes:

- Certification of repair technicians in accordance with EPA requirements

- Recovery of refrigerants during repair and prior to disposal
- Reuse or recycling of refrigerants
- Use of specific repair procedures
- Use of the smallest quantity and least harmful refrigerants possible, consistent with efficient research and facility operations.

Annual registration of the STM Campus and the Flatirons Campus as appliance repair facilities authorizes repair activities at these locations. Annual registration with the State of Colorado of two STM Campus appliances is required because of the ODS refrigerant they contain.

Drinking Water

Treated drinking water is provided to the STM Campus by Consolidated Mutual Water Company, a municipal water provider. Because of this, NREL does not have direct control over drinking water quality. However, NREL does maintain the integrity of the on-site distribution system and notifies Consolidated Mutual Water Company of any drinking water complaints.

When treated municipal water is hauled to the Flatirons Campus, chlorine is added to achieve proper disinfectant levels at the points of use. Drinking water quality is maintained and protected through water quality testing as specified by the monitoring plan issued each year by the Colorado Department of Public Health and Environment. The plan identifies which tests are to be performed and at what frequency. Monthly tests are required for bacteria and disinfectant levels. Testing for disinfection byproducts (haloacetic acids [HAA5] and trihalomethanes [TTHM]), lead, and copper is completed annually.

Groundwater

To protect groundwater quality, NREL carefully evaluates all outdoor projects to eliminate, substitute, or control potential sources of pollution. If any materials are used that pose a risk to groundwater, the laboratory incorporates safeguards such as secondary containment, double-walled tanks, leak detection, and collection and off-site disposal of concrete wash water.

When the laboratory conducts activities that could impact groundwater, NREL implements a monitoring program and groundwater monitoring wells are installed as needed. Occasionally groundwater wells may be installed and monitored to obtain water level data needed for construction or building maintenance purposes.

Surface Water

Surface water bodies to which NREL sites drain are protected by a management program that focuses on construction site runoff and outdoor research and maintenance activities.

For all construction projects, NREL implements an interdisciplinary planning and design process that includes NEPA review and assessment of design documents for potential impacts to stormwater and receiving waters. Design teams are encouraged to incorporate low-impact design elements that promote infiltration and evapotranspiration. NREL continues to monitor final design documents during construction for additional opportunities to reduce runoff volume and enhance runoff quality.

Erosion and sediment controls, proper chemical storage, fueling procedures, and good housekeeping practices are implemented during construction according to the stormwater management plans developed by contractors and reviewed by NREL staff. These documents are developed and reviewed for EPA-permitted sites as well as construction sites that do not require an EPA permit. While construction projects that disturb less than one acre are not regulated by the EPA and typically involve minimal disturbance within a short time frame, such projects still have the potential to contribute pollutants to stormwater runoff. These projects follow elements of the NREL stormwater pollution prevention program, including the development of a site-specific erosion and sediment control plan.

Regular inspections by contractors and staff are conducted throughout construction to verify that required controls are functioning properly. Any repairs or modifications to the plans are documented on an inspection report; prompt actions are required to correct any noncompliant conditions.

NREL manages areas outside active construction sites to minimize erosion, promote infiltration of rainwater and snowmelt, and prevent possible contamination of stormwater from exposure to materials stored outdoors. These objectives are accomplished by landscaping with native materials, revegetating site areas that have experienced a loss of vegetative cover, incorporating "low-impact development" elements in NREL design guidelines for new construction and redevelopment, and storing materials with the potential to contaminate stormwater either indoors or under cover.

The STM Campus operates under an EPA Region 8 Municipal Separate Storm Sewer System (MS4) permit that became effective in December 2018. During the first five-year permit term, programs will be developed that are needed for compliance with the permit's six minimum control measures. The programs will be instituted during subsequent permit terms.

Wastewater

NREL's wastewater management program is multifaceted and encompasses activities across the site, from using green cleaning supplies to minimizing harmful chemicals in laboratory operations. The program addresses the requirements of the Metro Wastewater Reclamation District, which receives and treats waste from the STM Campus, and it protects the groundwater aquifer to which the leach fields at the Flatirons Campus drain.

NREL has design guidelines for construction of new buildings and refurbishment of existing buildings to minimize the possibility of a hazardous material discharge. Examples of these requirements include measures to preclude inadvertent spills to sink drains, prohibition of floor drains in laboratory areas unless a specific need can be shown, and mandatory caps for floor drains that are installed in laboratory areas. New research and operations activities, as well as ongoing activities that undergo significant modifications, are reviewed through NREL's risk assessment process for their potential effect on wastewater. Regular training on appropriate rinsing and disposal practices when dealing with hazardous chemicals is provided to laboratory staff.

Hazardous Materials Management

In addition to EPCRA reporting obligations, a cornerstone of NREL's hazardous material management program is its laboratory-wide chemical management system. The system serves as a centralized chemical inventory and is a valuable tool for managing and reporting chemicals used at the laboratory. Using an electronic barcoding system, the chemical management system tracks chemicals from the point of receipt through end use and disposal. The system also contains technical data and reporting information for many of the chemicals in the chemical management system's database. Key functions of the system include:

- Providing current inventories by room, building, and campus
- Improving research efficiency and minimizing hazardous waste generation by allowing staff to determine whether needed chemicals are already available on-site before purchasing them
- Providing quick access to chemical inventories and hazard information during emergency responses
- Facilitating accurate and efficient reporting to external agencies (e.g., fire districts, state and local emergency response agencies, EPA, and DOE).

The chemical management system tracks chemical amounts, locations, and hazards, which helps NREL rigorously manage hazardous materials. Each week, safety personnel receive a list of the chemicals (and their hazards) shipped to the laboratory in the previous week. Researchers and safety personnel ensure chemicals are properly stored in locations suitable for their hazards (e.g., storing flammable materials in designated flammables cabinets).

When requested by the state and local emergency response agencies or local fire departments, additional emergency response and reporting information is provided. NREL has been represented on the Jefferson County Local Emergency Planning Committee since its inception and is actively involved in the emergency planning concepts of EPCRA, with two active members on the committee.

Emergency response plans are also in place in the event of a spill or release of a hazardous material; these plans are coordinated with state and local emergency planning and response agencies and first responders such as West Metro Fire Rescue, Rocky Mountain Fire Rescue, and the Jefferson County Local Emergency Planning Committee.

Hazardous Waste Management

Waste management and minimization efforts begin in the planning stages of all experimental and operational activities. Processes are evaluated based on the quantities and toxicities of products that will be brought on-site before an activity begins, and evaluations continue until material use is complete and materials are ready for disposal. Hazardous materials proposed for use are also assessed for the potential substitution of less hazardous products, which results in fewer hazardous waste streams.

The laboratory is committed to the appropriate management of regulated waste generated through its daily operations. These wastes are handled, stored, and disposed of responsibly and in accordance with regulatory requirements to minimize the potential for health and environmental impacts that could result from a release or improper disposal.

Implementation of regulatory requirements includes:

- A documented waste management and minimization program
- Annual training for all staff members who generate or handle regulated waste
- Regular inspection and tracking of all waste containers
- Storage, packaging, shipment, and tracking of wastes until final disposition at a properly permitted waste disposal or recycling facility
- Active monitoring of waste volumes to determine generator status
- Maintenance of records that are generated through "cradle-to-grave" waste management activities.

For select unregulated materials that still pose a potential hazard, NREL follows a conservative waste management policy wherein nonhazardous materials are collected and disposed of as nonhazardous materials at properly permitted disposal facilities. For example, nonhazardous nanomaterial-bearing wastes are not federally regulated but, because they pose a potential health risk, they are managed and disposed of using the same management methods used for hazardous waste. Waste streams are accumulated on-site for time frames are well within regulatory limits before being shipped for final disposal. In a general order of management preference, hazardous waste items are shipped off-site for final disposal via incineration, treatment, and landfill. Universal wastes are recycled or reclaimed.

Aboveground Storage Tank Management

NREL's AST management program applies to petroleum fuel tanks and is intended to:

- Minimize releases from tanks
- Confirm that safety features are present and functional
- Ensure compliance with tank design, operation, training, and inspection requirements.

The program consists of compliance, inspections, tank maintenance and improvements, training, and spill response. Staff actively participate in the program by:

- Participating in project planning, safety evaluations, and readiness verifications
- Conducting regular tank inspections and maintenance activities
- Achieving timely, necessary regulatory approval
- Maintaining a current and accurate AST inventory
- Placing spill response supplies in key locations
- Planning and documenting of annual training activities.

Personnel who operate and manage ASTs are trained annually on program requirements, including inspection and response requirements, the spill history of each site, lessons learned, and recent changes in rules and regulations.

Several important mechanical and procedural safeguards have been incorporated into NREL's AST management program to prevent an accidental release of diesel or E-85 fuel from the storage tanks. Mechanical safeguards include overfill and spill protection, double-walled tanks equipped with sensors that result in an alarm if the inner tank wall is leaking, and secondary containment for single-walled tanks. Procedural safeguards include written operating and tank-filling procedures, monthly and annual inspections, and recordkeeping of inspection results. ASTs larger than 60 gallons (227 L) are visually inspected monthly and all double-walled ASTs are inspected annually to confirm there is no liquid in the interstitial space.

Spill Prevention and Response

The laboratory prepares for and continually improves spill response procedures. Formal SPCC plans have been developed and are periodically updated for the Flatirons Campus, the STM Campus, and the Renewable Fuels and Lubricants Research Laboratory. The plans are designed to minimize the number and size of spills, as well as facilitate the efficient cleanup of spilled materials. SPCC plans are updated every three years or whenever regulations, operations, or equipment changes significantly. The laboratory's aggressive approach to spill prevention and control exceeds the EPA's requirement that SPCC plans be updated at least every five years.

Emergency notification and hazardous materials procedures are in place to provide additional support for spill response. Proper preventive planning and training minimizes the potential for spills, and advance preparation for spill response protects water and ecological resources.

SPCC training occurs annually for individuals who are responsible for oil-containing equipment and AST operation and maintenance. SPCC training is combined with AST training and educates staff on oil-containing equipment at each site. Training covers inspection and response requirements, location and use of spill response equipment, identification of spill control locations, and notification and spill reporting protocols.

The laboratory typically does not experience spills that require notification to federal or state agencies. Small, incidental hydraulic system leaks, lubricant leaks, and fuel transfer spills may occasionally occur. NREL policy is that spills, regardless of their size, are to be reported to the NREL Central Monitoring Station. This policy makes clear that reporting of and responding to any spill are important to NREL and DOE. Lessons learned from spill incidents and clean-up activities are used to improve management and spill response planning.

Spill response kits containing sorbent materials are strategically placed at each NREL facility near where spills might occur. Spill kits are periodically evaluated as laboratory activities change over time.

Radiological Materials

Through its radiation safety program, NREL has established strict protocols for radiation-generating devices, equipment containing sources of radiation, and the use of radioisotopes in laboratory experiments. Some of these controls include:

- Confining work with radioisotopes to a small number of specific laboratories

- Limiting the types and quantities of radioisotopes on-site
- Monitoring equipment and facilities for removable contamination or sealed-source leakage.

No radioactive air emission monitoring is conducted at the laboratory because of the extremely low use of radioactive materials. In lieu of monitoring, NREL demonstrates compliance with radiological air emission standards by using an EPA computer model (COMPLY Version 1.6) to determine the effective dose equivalent to the public.

Current laboratory procedures prohibit any activity that may result in a radioactive waste that is federally regulated under the Resource Conservation and Recovery Act and is categorized as "mixed waste." Therefore, all radioactive waste generated is classified solely as low-level radioactive waste. Waste is temporarily stored on-site until disposal is arranged at an off-site facility permitted to accept low-level radioactive waste. Internal procedures prohibit the disposition of property unless it has been decontaminated to background levels.

NEPA

Once a project is proposed, the NEPA process is initiated and must be completed before the proposed project or activity begins. In accordance with regulations, all NREL activities (both on- and off-site) must undergo a NEPA review to evaluate and understand the potential environmental impacts of a project. The outcome of such a review is the NEPA determination. A final NEPA determination must be signed before federal funds are expended, before a contract award can be made, and before project activities begin.

NREL and DOE's Golden Field Office use site-wide environmental assessments (EAs) to streamline the environmental review process. These documents represent comprehensive analyses of potential environmental impacts associated with NREL's current and future actions over 5–10 years at both the STM Campus and the Flatirons Campus. The environmental assessments serve as planning tools that aid ongoing and future operational and development decisions related to NREL's sites. The Site-Wide EAs for the STM Campus and the Flatirons Campus provide a baseline environmental analysis that streamlines future environmental reviews, improves and coordinates site and agency planning, and maximizes cost savings.

NREL and the DOE Golden Field Office have developed several Programmatic NEPA Determinations to further streamline the environmental review process for recurring activities that have minimal environmental impacts. These activities generally involve business and administrative actions, information gathering and technical advice, and bench-scale research and development. The Programmatic NEPA Determinations are based on the existing site-wide EAs or DOE Categorical Exclusions and are reviewed annually for applicability and appropriateness.

Using the Site-Wide EAs and Programmatic NEPA Determinations, DOE and NREL analyze administrative, operational, and research activities and place each in one of three categories to streamline the environmental review process. Each category is briefly described below:

- **Require No Further NEPA Review:** Actions under this category have been assessed by DOE and NREL and have been determined to have negligible environmental impacts.
- **Require a NEPA Sufficiency Review:** These actions may have minimal potential for environmental impacts and require a sufficiency review by the NREL NEPA Coordinator.
- **Require Further NEPA Review and Documentation by DOE:** Actions in this category have a greater potential for environmental impacts, involve actions with a federal agency or foreign government, or require the application of a categorical exclusion. DOE must complete the NEPA review.

If a proposed activity has not already been evaluated in an existing Site-Wide EA or Programmatic NEPA Determination, further environmental analysis must be conducted. Potential environmental impacts of an activity are evaluated and measures are taken as needed to avoid or minimize those impacts. The level of review conducted is appropriate to the potential impacts of the proposed activity. For example, a proposed construction project would receive a more rigorous review than routine office or laboratory work.

Wildlife Management

NREL's wildlife management program was developed to implement measures to meet or exceed regulatory requirements and minimize or avoid impacts to wildlife species and their habitats. Regulatory requirements include the Migratory Bird Treaty Act, a state statute prohibiting the harassment of wildlife (including damaging/destroying dens or nests), a Memorandum of Understanding between DOE and the USFWS to promote the conservation of migratory bird populations, and a presidential memorandum to promote the health of honey bees and other pollinators.

Several laboratory activities help achieve the program's intent, including the following:

- **Monitoring:** The laboratory conducts nesting bird surveys before any ground- or vegetation-disturbing activities are conducted between mid-March and mid-September every year. If nests are found, the area is closed and a buffer area is established until nestlings fledge. Staff also periodically conduct site-wide surveys to document biological conditions.

- **Project Reviews:** Biologists conduct project reviews to assess and reduce potential impacts to wildlife.
- **Coordination:** Biologists coordinate with local, state, and federal agencies to improve wildlife management in concert with surveys for threatened and endangered species and habitats. Because habitat is as much a concern as the wildlife species themselves, program activities often overlap with vegetation management.

Other program goals include maintaining wildlife movement through the STM Campus by retaining access to the adjacent conservation easement north of the site and to Pleasant View Community Park and Lena Gulch to the south. At the Flatirons Campus, ecologically sensitive areas and linkages with surrounding open space areas are preserved.

When control of pest wildlife species is necessary, a graded approach is used to humanely control pests and minimize other potential impacts. Building design features and administrative controls are the first line of defense against pests. When these are not fully effective, additional controls are used. Native wildlife pests are relocated whenever possible. When pests must be destroyed, mechanical methods are preferred over poisoning. When necessary, pesticides are selected that pose the least-harmful effects to non-target wildlife

Endangered Species and Species of Concern

Periodic surveys are conducted at the Flatirons Campus and STM Campus to determine the presence or absence of species that are listed under the federal ESA as threatened or endangered. These include the Preble's meadow jumping mouse (*Zapus hudsonius preblei*), the Ute ladies' tresses orchid (*Spiranthes diluvialis*), and the Colorado butterfly plant. However, on November 5, 2019, the USFWS delisted the Colorado butterfly plant as a threatened species as a result of its recovery. To date, none of these species has been identified at either of NREL's campuses. Species of special concern listed by the USFWS on the Information for Planning and Consultation website[9], as well as species listed by the State of Colorado as rare plants, species of special concern, or species of greatest conservation concern are surveyed. These baseline surveys, which are typically conducted every five years, are a vital part of the laboratory's NEPA program by which impacts to natural resources from mission activities are assessed.

The USFWS has designated critical habitat associated with the Preble's meadow jumping mouse within the upper reaches of Rock Creek, including a small area at the southeastern corner of the Flatirons Campus. This area may not be disturbed without coordination with the USFWS.

In accordance with the ESA, the USFWS lists five other species occurring in the Platte River watershed in Nebraska that must be considered for projects in Colorado and Wyoming that may deplete water supplies to the Platte River system. These include:

- Three birds species: the Piping plover (*Charadrius melodus*), the Whooping crane (*Grus americana*), and the Least tern (*Sternula antillarum*)
- A fish species: the Pallid sturgeon (*Scaphirhynchus albus*)
- A plant species: the western prairie fringed orchid (*Platanthera praeclara*).

For any NREL activities that may deplete water in the Platte River system, consultation with the USFWS must be completed to determine potential impacts.

Vegetation Management

The focus of NREL's vegetation management program is to:

- Conserve existing ecosystems in their natural state as much as possible
- Strive to replace disturbed vegetation with native species, or with adapted but noninvasive species when necessary
- Implement a program of weed management to prevent the spread of noxious weeds and implement measures to control these species.

To maintain existing native vegetation and to ensure the success of revegetated areas, the laboratory has developed sustainable landscape management practices that:

- Provide supplemental water during seedling growth and establishment, and minimize water use thereafter
- Reduce the need for and use of pesticides and fertilizers
- Reduce maintenance costs
- Maximize ground cover to reduce soil erosion
- Establish a variety of habitats to support diverse wildlife
- Create an aesthetically pleasing landscape.

When removal of native vegetation cannot be avoided, reseeding is done using grass and forb seed mixes native to the local area. A suite of native flowering plants, shrubs, and trees has been identified for use on both the STM Campus and the Flatirons Campus to enhance ecosystem diversity and integrity. NREL staff continually evaluate and modify revegetation techniques as needed to promote healthy plant establishment.

NREL participated in a Sustainable Sites Initiative two-year pilot program (2010–2012) established by the American Society of

9. "IPaC Information for Planning and Consultation," U.S. Fish and Wildlife Service, https://ecos.fws.gov/ipac/

Landscape Architects, the Lady Bird Johnson Wildflower Center at the University of Texas at Austin, the United States Botanic Garden, and a diverse group of other stakeholders. The pilot program was intended to develop the first national rating system for sustainable landscapes. Certification under the program demonstrates that the stewardship activities needed for sustaining healthy ecosystems are being implemented. NREL developed and submitted a plan for implementing sustainable landscape practices and received a rating of three out of four stars. The plan is now integrated into NREL's landscape maintenance plan and other relevant site-wide procedures. Integrated components of the plan include plant stewardship, invasive species management, organic materials management, soil stewardship, irrigation and water use, stormwater management, materials management, snow and ice management, and monitoring. The Sustainable Sites Initiative also serves as a critical foundation that supports NREL's objective in creating adaptive and resilient sites to meet the challenge of dynamic climate changes.

NREL uses an integrated weed management approach that incorporates various types of weed control methods, including:

- Mechanical practices (e.g., mowing or pulling weeds by hand)
- Cultural practices (e.g., reclaiming disturbed areas)
- Prevention (e.g., limiting or eliminating driving of vehicles off established roadways)
- Biological practices (e.g., introducing living organisms such as fungus or insects that have a preference for certain weed species)
- Treatment using herbicides.

The use of multiple strategies for control has been successful in significantly reducing populations of diffuse knapweed (*Centaurea diffusa*) and Canada thistle (*Cirsium arvense*). The weed control program maintains the flexibility needed to respond to changes in weed populations from year to year. Periodic mapping of weed infestation areas helps target weed control efforts.

The laboratory continues to address the control of these species using the integrated weed management approach described above, and periodically assess the effectiveness of these control methods. Comprehensive site-wide weed surveys and mapping are performed approximately every five years; smaller areas of NREL's main sites are assessed annually.

Wildfire Risk Management

Because wildfires have the potential to affect DOE property and impact operational activities, NREL has developed a fire protection program that addresses wildfire. To protect buildings, infrastructure, and outdoor research from wildfire, NREL evaluates the wildland-urban interface on DOE properties. Areas within the interface are actively managed to reduce fuel sources. Management activities include mowing vegetation, herbicide application in graveled areas, and shrub and tree removal where applicable. At both the STM Campus and the Flatirons Campus, vegetation management is balanced with maintaining native vegetation and wildlife habitat. At the Flatirons Campus, water tanks are inspected regularly to ensure firefighting resources are available should a wildfire occur.

Imported Plants and Organisms

NREL's vegetation management program also addresses the use of certain animal (pathogen) and plant species brought to the laboratory for research purposes, primarily for biofuels and biomaterials investigations. Some of the plants and pathogens obtained from other states or from outside the United States are controlled by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), and they require permitting to protect against their release into either the immediate work area or to the outside environment. In addition to the required management practices identified in APHIS-issued permits, management of these materials is also controlled through NREL's Biosafety Program. This program provides guidance to researchers on various aspects of working with biological materials, such as the identification of materials that can and cannot be used at NREL, when approvals are required by NREL's Institutional Biosafety Panel, and good laboratory practices.

Wetlands and Floodplains

NREL protects its wetlands and floodplains by:

- Periodically surveying vegetation and wetland delineations
- Mapping wetland areas potentially affected by proposed construction
- Identifying potential impacts
- Coordinating with other jurisdictions on the control of floodwaters leaving the STM Campus or the Flatirons Campus.

The U.S. Army Corps of Engineers has examined the STM Campus drainages and determined that they do not meet jurisdictional wetland criteria and are not currently regulated. The U.S. Army Corps of Engineers has not evaluated site drainages on the Flatirons Campus.

Functional wetlands, whether regulated or unregulated, are considered valuable features that serve many ecological functions, and the laboratory seeks to protect these to the maximum extent practicable from site development.

Cultural Resources

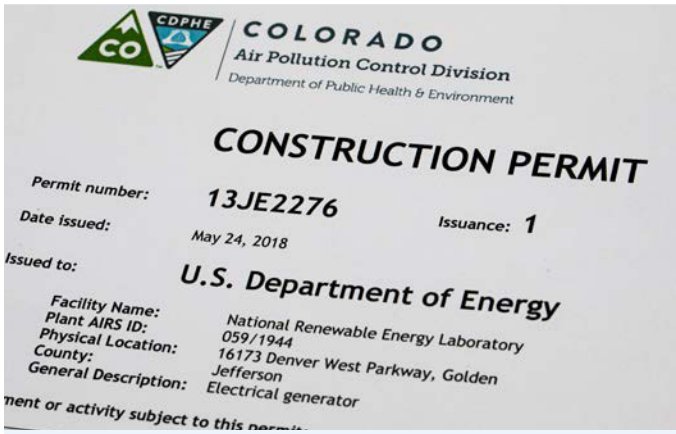
Cultural resources are protected at NREL by:

- Integrating cultural resource management into site activities, and minimizing and mitigating impacts to historic properties and features
- Implementing procedures to manage historic features and protect undiscovered cultural resources and artifacts
- Periodically conducting surveys to document the presence or absence of cultural or historic resources and working with the Colorado Office of Archaeology and Historic Preservation to determine how to proceed should any evidence of cultural resources be discovered during surveys or ground-disturbing activities. For example, workers are to stop all work in the vicinity of a find until a qualified archaeologist evaluates its significance.

Conservation Lands

Approximately 177 acres (72 hectares) at the STM Campus have been granted by DOE to Jefferson County as a conservation easement. This area is maintained by NREL as a natural landscape. Each year, at least one visual inspection of the conservation easement property is conducted to identify management activities needed to address erosion, weed management, trail conditions, or other issues that may exist.

At the Flatirons Campus, approximately 60 acres (24 hectares) of land are managed as a conservation area. Development is limited in this area, and the land is managed to conserve specific features, including seeps, ephemeral drainages, ponds, native grassland habitat, areas supporting ancient soils (i.e., a soil structure in association with plant species forming a stable ecological community that is resistant to weed invasion), a small area designated as critical habitat for the Preble's meadow jumping mouse, and a rocky outcropping supporting ponderosa pine and shrublands.



APPENDIX B.

ENVIRONMENTAL PERMITS, REGISTRATIONS, AND NOTIFICATIONS

NREL obtains numerous permits and registrations to ensure environmental compliance. *Photo by Werner Slocum, NREL 56778*

Table B-1. NREL Environmental Permits, Registrations, and Notifications in 2019

NREL Environmental Permits, Registrations, and Notifications in 2019					
Type	Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
AST for petroleum storage	STM ESIF: AST	Registration	DOPS	19275-1	No longer in effect
AST for petroleum storage	STM PDU: AST	Registration	DOPS	2873-2	No longer in effect
AST for petroleum storage	STM RSF2: AST	Registration	DOPS	19211-1	No longer in effect
AST for petroleum storage	STM SERF: AST	Registration	DOPS	2873-1	No longer in effect
AST for petroleum storage	STM E85: AST	Registration	DOPS	2873-4	No longer in effect
Air	Laboratory-wide: servicing of CFC-containing equipment	Notification	APCD	647	Completed
Air	STM SERF: 2 CFC-containing stationary sources	Registration	APCD	647	Completed
Air	STM FTLB: waste gas combustor	Permit	APCD	99JE0400	Active

NREL Environmental Permits, Registrations, and Notifications in 2019					
Type	Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
Air	STM RFHP: wood waste boiler	Permit	APCD	07JE0277	Active
Air	STM: fugitive dust from construction activities	Permit	APCD	08JE0889L	Active
Air	STM RSF 1: diesel-fired standby electrical generator	Permit	APCD	10JE1400	Active
Air	STM RSF 2: diesel-fired standby electrical generator	Permit	APCD	11JE1303	Active
Air	STM FTLB: diesel-fired standby electrical generator	Permit	APCD	10JE1630	Active
Air	FC Site 4.0: diesel-fired standby electrical generator	Permit	APCD	10JE1712	Active
Air	STM ESIF: diesel-fired standby electrical generator	Permit	APCD	11JE3542	Active
Air	STM ESIF: research electrical generator #3	Permit	APCD	13JE2829	Active
Air	STM IBRF: NH_3 scrubber and baghouse	Permit	APCD	11JE1798	Active
Air	STM ESIF: research electrical generator #1	APEN	APCD	12JE1734 XP	Active
Air	STM ESIF: research electrical generator #2	APEN	APCD	12JE1735 XP	Active
Air	STM IBRF: standby electrical generator	Permit	APCD	13JE2276	Active
Air	FC STL: standby electrical generator	APEN	APCD	13JE2271 XP	Active
Air	FC Building 251: standby electrical generator	APEN	APCD	13JE2272 XP	Active
Air	FC CoMET: facility composite demonstration facility	APEN	APCD	16JE0934 XP	Active
Air	FC Site 4.4: diesel-fired standby electrical generator	APEN	APCD	13JE2270 XP	Active
Air	STM S&TF: standby electrical generator	APEN	APCD	13JE2274 XP	Active
Air	STM SERF: standby electrical generator	APEN	APCD	13JE2275 XP	Active
Alcohol	STM IBRF: alcohol fuel production	Permit	TTB	AFP-CO-00255	Active

NREL Environmental Permits, Registrations, and Notifications in 2019

Type	Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
Alcohol	Laboratory-wide: tax-free alcohol use	Permit	TTB	TF-CO-0331	Terminated
Alcohol	Laboratory-wide: tax-free alcohol use	Permit	TTB	US-TF-20125	Active
Animals, Plants	STM CIP to import *Agrobacterium tumefaciens* from within the United States.	Permit	APHIS	P526P-16-03695	Terminated, renewed under new CIP
Animals, Plants	STM CIP to import *Agrobacterium tumefaciens* from within the United States.	Permit	APHIS	P526-16-02851	Active
Animals, Plants	STM CIP to import *Goronia*, *Aquitalea*, *Cupriavidus*, *Gulbenkiania*, *Novosphingobium*, *Pseudogulbenkiania*, *Roseatles* from Puerto Rico or U.S. Virgin Islands	Permit	APHIS	P526-16-00476	Terminated
Animals, Plants	STM CIP to import *Sphingobium* spp. from Japan	Permit	APHIS	P526P-18-02318	Active
Drinking water system	FC: drinking water system ID number	Registration	WQCD	CO0230860	In effect; does not expire
Groundwater well	STM FTLB: groundwater monitoring well MW-FTLB-1	Permit	DWR	301322	Active
Groundwater well	STM FTLB: groundwater monitoring well MW-FTLB-2	Permit	DWR	301323	Active
Groundwater well	STM FTLB: groundwater monitoring well MW-FTLB-3	Permit	DWR	301324	Active
Hazardous materials	STM WHF: hazardous material storage and use permit	Permit	WMFR	N/A	Completed
Hazardous materials	STM SERF: hazardous material storage and use permit	Permit	WMFR	N/A	Completed
Hazardous materials	STM S&TF: hazardous material storage and use permit	Permit	WMFR	N/A	Completed
Hazardous materials	STM FTLB: hazardous material storage and use permit	Permit	WMFR	N/A	Completed
Hazardous materials	STM IBRF: hazardous material storage and use permit	Permit	WMFR	N/A	Completed

NREL Environmental Permits, Registrations, and Notifications in 2019

Type	Location: Description	Category	Issuing Agency	ID	Permit or Registration Status
Hazardous materials	STM Shipping and Receiving: hazardous material storage and use permit	Permit	WMFR	N/A	Completed
Hazardous materials	Denver West Office Park Building 16: hazardous material storage and use permit	Permit	WMFR	N/A	Completed
Hazardous materials	STM ESIF: hazardous material storage and use permit	Permit	WMFR	N/A	Completed
Hazardous materials	ReFUEL: hazardous material storage and use permit	Permit	Denver Fire Department	197016	Completed
Hazardous waste	Denver West Office Park Building 16: RCRA hazardous waste generator status EPA ID	Notification	HMWMD	CO4890000017	Completed
Hazardous waste	STM: RCRA hazardous waste generator status EPA ID	Notification	HMWMD	CO3890090076	Completed
Hazardous waste	JSF: RCRA hazardous waste generator status EPA ID	Notification	HMWMD	COD980805162	Completed (pending closure)
Hazardous waste	FC: RCRA hazardous waste generator status EPA ID	Notification	HMWMD	COD983902448	Completed
Hazardous waste	ReFUEL: RCRA hazardous waste generator status EPA ID	Notification	HMWMD	COR000207563	Completed
Historic registration	STM: amphitheater	Registration	NPS	93000378	In effect; does not expire
Historic registration	STM: stone bunker	Registration	NPS	93000379	In effect; does not expire
Stormwater	STM SERF & S&TF: Landscape Improvements/ Site Improvements	Permit	EPA	COR10F00K	Active
Stormwater	FC: Site Improvements, Power Generation Upgrade, and Secondary Feeder	Permit	EPA	COR10F028	Active
Stormwater	STM: Municipal Separate Storm Sewer System (MS4)	Permit	EPA	COR042009	Active

Acronyms used in the table:

APCD Air Pollution Control Division (CDPHE)

APEN Air Pollutant Emission Notice

APHIS Animal and Plant Health Inspection Service (U.S. Department of Agriculture)

AST aboveground storage tank

CDPHE Colorado Department of Public Health and Environment

CFC chlorofluorocarbon

CIP controlled import permit

CoMET Composites Manufacturing Education and Technology

DFD Denver Fire Department

DOPS Division of Oil and Public Safety (Colorado Department of Labor and Employment)

DWR Division of Water Resources (State of Colorado)

EPA Environmental Protection Agency (United States)

ESIF Energy Systems Integration Facility

FC Flatirons Campus

FTLB Field Test Laboratory Building

HMWMD Hazardous Materials and Waste Management Division (CDPHE)

IBRF Integrated Biorefinery Research Facility

JSF Joyce Street Facility

NPS National Park Service (U.S. Department of the Interior)

PDU process development unit

RCRA Resource Conservation and Recovery Act

ReFUEL Renewable Fuels and Lubricants Research Laboratory

RFHP Renewable Fuel Heat Plant

RSF Research Support Facility

S&TF Science and Technology Facility

SERF Solar Energy Research Facility

STM South Table Mountain

TTB Alcohol and Tobacco Tax and Trade Bureau (U.S. Department of the Treasury)

WHF Waste Handling Facility

WMFR West Metro Fire Rescue

WQCD Water Quality Control Division (CDPHE)

The colorful Bullock's Oriole (*Icterus bullockii*) arrives in May and is a summer resident on the STM Campus.
Photo by Werner Slocum, NREL 56731

APPENDIX C.

WILDLIFE SPECIES OBSERVED AT THE STM CAMPUS AND THE FLATIRONS CAMPUS

The following are lists of wildlife species observed at the STM Campus (Table C-1) and the Flatirons Campus (Table C-3).

Species listed for the STM Campus were observed by staff and/or observed in surveys completed in 1987, 2005, 2011, and 2017. For 1987 survey results, refer to NREL's *Environmental Performance Report 2016*.[10]

The species for the Flatirons Campus were identified during surveys completed in 1996, 2003, 2011, and 2016. For the 1996 survey results, refer to NREL's *Environmental Performance Report 2015*.[11]

Table C-1. Wildlife Species at the STM Campus

Species Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
BIRDS				
American Coot	*Fulica americana*			X
American Crow	*Corvus brachyrhynchos*	X	X	X
American Goldfinch	*Carduelis tristis*		X	X
American Kestrel	*Falco sparverius*	X	X	X
American Pipit	*Anthus rubescens*		X	X
American Redstart	*Setophaga ruticilla*		X	X
American Robin	*Turdus migratorius*	X	X	X
American Tree Sparrow	*Spizella arborea*	X	X	
American White Pelican	*Pelecanus erythrorhynchos*		X	
Bald Eagle[a]	*Haliaeetus leucocephalus*			
Barn Swallow	*Hirundo rustica*		X	X
Black-billed Magpie	*Pica hudsonia*	X	X	X
Black-capped Chickadee	*Poecile atricapilla*	X		X

10. NREL (National Renewable Energy Laboratory). 2016. *Environmental Performance Report 2016: Annual Site Environmental Report per the U.S. Department of Energy Order 231.B Chg 1*. Golden, CO: National Renewable Energy Laboratory. NREL/MP-1900-68671. https://www.nrel.gov/docs/fy17osti/68671.pdf.

11. NREL. 2016. *Environmental Performance Report 2015: Annual Site Environmental Report per the U.S. Department of Energy Order 231.B*. Golden, CO: National Renewable Energy Laboratory. NREL/MP-1900-65807. https://www.nrel.gov/docs/fy16osti/65807.pdf.

Species Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Black-crowned Night Heron	*Nycticorax nycticorax*	X		
Black-headed Grosbeak	*Pheucticus melanocephalus*		X	
Blue-gray Gnatcatcher	*Polioptila caerulea*		X	
Blue Jay	*Cyanocitta cristata*	X	X	
Blue-winged Teal[a]	*Spatula discors*			
Brewer's Blackbird	*Euphagus cyanocephalus*		X	
Brewer's Sparrow	*Spizella breweri*		X	X
Broad-tailed Hummingbird	*Selasphorus platycercus*		X	X
Broad-winged Hawk	*Buteo platypterus*		X	
Brown-headed Cowbird	*Molothrus ater*	X	X	X
Bullock's Oriole	*Icterus bullockii*	X	X	X
Bushtit	*Psaltriparus minimus*		X	
California Gull	*Larus californicus*	X		
Canada Goose	*Branta canadensis*	X	X	
Cedar Waxwing	*Bombycilla cedrorum*		X	
Cassin's Kingbird	*Tyrannus vociferans*		X	X
Chestnut-collared Longspur	*Calcarius ornatus*		X	
Chipping Sparrow	*Spizella passerina*		X	X
Clay-colored Sparrow	*Spiella pallida*			X
Cliff Swallow	*Petrochelidon pyrrhonota*		X	X
Common Grackle	*Quiscalus quiscula*		X	X
Common Nighthawk	*Chordeiles minor*	X	X	X
Common Raven	*Corvus corax*	X	X	X
Common Yellowthroat	*Geothlypis trichas*			X
Cooper's Hawk	*Accipiter cooperii*	X	X	
Dark-eyed Junco	*Junco hyemalis*	X	X	X
Double-crested Cormorant	*Phalacrocorax auritus*		X	X
Eastern Kingbird	*Tyrannus tyrannus*		X	
Eurasian Collared-Dove	*Streptopelia decaocto*			X
European Starling	*Sturnus vulgaris*	X	X	X
Golden Eagle	*Aquila chrysaetos*	X		
Grasshopper Sparrow	*Ammodramus savannarum*		X	
Gray Catbird	*Dumetella carolinensis*			X

Species Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Great Blue Heron	*Ardea herodias*	X	X	
Great Horned Owl	*Bubo virginianus*			X
Greater Roadrunner[a]	*Geococcyx californianus*			
Green-tailed Towhee	*Pipilo chlorurus*		X	
Hammond's Flycatcher	*Empidonax hammondii*			X
Hepatic Tanager	*Piranga flava*		X	
Hermit Thrush	*Catharus guttatus*		X	
Horned Lark	*Eremophila alpestris*		X	
House Finch	*Carpodacus mexicanus*	X	X	X
House Sparrow	*Passer domesticus*	X	X	X
House Wren	*Troglodytes aedon*		X	X
Killdeer	*Charadrius vociferous*	X	X	
Lark Bunting	*Calamospiza melanocorys*	X		
Lark Sparrow	*Chondestes grammacus*		X	X
Lazuli Bunting	*Passerina amoena*		X	
Lesser Goldfinch	*Carduelis psaltria*		X	X
Lincoln's Sparrow	*Melospiza lincolnii*			X
Loggerhead Shrike	*Lanius ludovicianus*	X		
Macgillivray's Warbler	*Oporornis tolmiei*	X		
Mallard	*Anas platyrhynchos*	X		
Mountain Bluebird	*Sialia currucoides*	X		X
Mountain Chickadee	*Poecile gambeli*		X	
Mourning Dove	*Zenaida macroura*	X		X
Northern Flicker	*Colaptes auratus*	X		X
Northern Goshawk	*Accipiter gentilis*		X	
Northern Harrier	*Circus cyaneus*	X		X
Northern Mockingbird	*Mimus polyglottos*			X
Northern Pygmy-Owl	*Glaucidium californicum*			X
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*			X
Northern Saw-whet Owl[a]	*Aegolius acadicus*			
Orange-crowned Warbler[a]	*Oreothlypis celata*			
Osprey	*Pandion haliaetus*	X		X

Species Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Peregrine Falcon	*Falco peregrinus*		X	
Pine Siskin	*Carduelis pinus*		X	
Prairie Falcon	*Falco mexicanus*	X		X
Red-breasted Nuthatch	*Sitta canadensis*	X		X
Red-tailed Hawk	*Buteo jamaicensis*	X		X
Red-winged Blackbird	*Agelaius phoeniceus*			X
Rock Dove	*Columba livia*	X		X
Rock Wren	*Salpinctes obsoletus*	X		
Ruby-crowned Kinglet	*Regulus calendula*		X	
Sage Thrasher	*Oreoscoptes montanus*		X	X
Say's Phoebe	*Sayornis saya*	X		X
Sharp-shinned Hawk	*Accipiter striatus*		X	X
Spotted Towhee	*Pipilo maculates*	X		X
Swainson's Hawk	*Buteo swainsoni*	X		
Tree Swallow	*Tachycineta bicolor*	X	X	X
Turkey Vulture	*Cathartes aura*	X		X
Vesper Sparrow	*Pooecetes gramineus*	X		X
Virginia's Warbler	*Oreothlypis virginiae*		X	
Violet-green Swallow	*Tachycineta thalassina*		X	X
Western Kingbird	*Tyrannus verticalis*	X		X
Western Meadowlark	*Sturnella neglecta*	X		X
Woodhouse's (Western) Scrub-Jay	*Aphelocoma californica*	X		X
White-crowned Sparrow	*Zonotrichia leucophrys*	X		X
White-faced Ibis	*Plegadis chihi*		X	
White-throated Swift	*Aeronautes saxatalis*		X	
Wilson's Snipe	*Gallinago delicata*	X		
Yellow Warbler	*Setophaga petechia*			X
Yellow-breasted Chat	*Icteria virens*		X	X
Yellow-rumped Warbler	*Dendroica coronata*		X	
MAMMALS				
Big brown bat[a]	*Eptesicus fuscus*			
Black bear[a]	*Ursus americanus*			

Species Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
Black-tailed jackrabbit	*Lepus californicus*		X	
Bobcat[a]	*Lynx rufus*			
Bushy-tailed woodrat[a]	*Neotoma cinerea*			
Common muskrat[a]	*Ondatra zibethicus*			
Coyote	*Canis latrans*	X	X	
Deer mouse	*Peromyscus maniculatus*		X	
Elk[a]	*Cervus canadensis*			
Fox squirrel	*Sciurus niger*	X		
Hoary bat	*Lasiurus cinereus*			X
Long-tailed weasel	*Mustela frenata*	X		
Mexican woodrat	*Neotoma mexicana*	X	X	
Mountain cottontail	*Sylvilagus nuttalli*	X	X	X
Mule deer	*Odocoileus hemionus*	X	X	
Prairie vole	*Microtus ochrogaster*	X		
Raccoon	*Procyon lotor*	X	X	
Red fox	*Vulpes vulpes*		X	
Striped skunk	*Mephitis*		X	
Western harvest mouse	*Reithrodontomys megalotis*	X	X	
Western spotted skunk	*Spilogale gracilis*		X	
White-tailed jackrabbit	*Lepus townsendii*	X		
REPTILES AND AMPHIBIANS				
Boreal chorus frog	*Pseudacris maculata*		X	X
Bull snake	*Pituophis catenifer*		X	
Plains garter snake	*Thamnophis radix*	X		
Prairie lizard	*Sceloporus consobrinus*		X	
Six-lined racerunner	*Cnemidophorus sexlineatus*	X		
Wandering garter snake[a]	*Thamnophis elegans*			
Tiger salamander	*Ambystoma tigrinum*	X	X	X
Western (Prairie) rattlesnake	*Crotalus viridus*	X	X	
Woodhouse's toad	*Anazyrus woodhousii*		X	
Yellow-bellied Racer	*Coluber constrictor*		X	

[a] Species observed at a time other than during a survey

Table C-2. Wildlife Species at the Flatirons Campus

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
BIRDS				
American Crow	*Corvus brachyrhynchos*		X	
American Goldfinch	*Spinus tristis*	X	X	
American Kestrel	*Falco sparverius*	X	X	X
American Pipit	*Anthus rubescens*		X	
American Robin	*Turdus migratorius*	X	X	X
American Tree Sparrow	*Spizella arborea*		X	
Bald Eagle	*Haliaeetus leucocephalus*		X	
Barn Swallow	*Hirundo rustica*	X	X	X
Black-billed Magpie	*Pica hudsonia*	X	X	X
Black-capped Chickadee	*Poecile atricapillus*	X	X	
Blue-gray Gnatcatcher	*Polioptila caerulea*	X		X
Blue Jay	*Cyanocitta cristata*		X	
Brewer's Blackbird	*Euphagus cyanocephalus*	X	X	X
Brewer's Sparrow	*Spizella breweri*		X	
Broad-tailed Hummingbird	*Selasphorus platycercus*	X	X	X
Broad-winged Hawk[a]	*Buteo platypterus*			
Brown-headed Cowbird	*Molothrus ater*	X	X	
Bullock's Oriole	*Icterus bullockii*		X	X
Canada Goose	*Branta canadensis*		X	X
Cedar Waxwing	*Bombycilla cedrorum*		X	
Chipping Sparrow	*Spizella passerina*	X	X	
Cliff Swallow	*Petrochelidon pyrrhonota*	X		
Common Grackle	*Quiscalus quiscula*	X	X	
Common Nighthawk	*Chordeiles minor*	X		X
Common Raven	*Corvus corax*	X	X	X
Cooper's Hawk[a]	*Accipiter cooperii*			
Dark-eyed Junco	*Junco hyemalis*		X	
Double-crested Cormorant	*Phalacrocorax auritus*	X		X
Downy Woodpecker	*Picoides pubescens*		X	
Eurasian Collared-Dove	*Streptopelia decaocto*		X	
European Starling	*Sturnus vulgaris*	X	X	X

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Ferruginous Hawk	*Buteo regalis*	X	X	
Franklin's Gull	*Larus pipixcan*		X	
Golden Eagle[b]	*Aquila chrysaetos*	X	X	
Grasshopper Sparrow	*Ammodramus savannarum*	X	X	X
Gray Catbird	*Dumetella carolinensis*		X	X
Great Blue Heron	*Ardea herodias*	X	X	X
Great Horned Owl	*Bubo virginianus*		X	X
Green-tailed Towhee	*Pipilo chlorurus*	X		X
Hairy Woodpecker	*Picoides villosus*		X	
Horned Lark	*Eremophila alpestris*	X	X	
House Finch	*Carpodacus mexicanus*	X	X	X
House Wren	*Troglodytes aedon*			X
Killdeer	*Charadrius vociferus*		X	X
Lark Bunting	*Calamospiza melanocorys*		X	
Lark Sparrow	*Chondestes grammacus*	X		X
Loggerhead Shrike	*Lanius ludovicianus*		X	
Long-billed Curlew	*Numenius americanus*		X	
Mallard	*Anas platyrhynchos*	X	X	
Mountain Bluebird	*Sialia currucoides*	X	X	
Mountain Chickadee	*Poecile gambeli*		X	
Mourning Dove	*Zenaida macroura*	X	X	X
Northern Flicker	*Colaptes auratus*	X	X	
Northern Harrier	*Circus cyaneus*	X	X	
Peregrine Falcon	*Falco peregrinus*	X	X	
Prairie Falcon	*Falco mexicanus*	X		
Red-headed Woodpecker	*Melanerpes erythrocephalus*		X	
Red-tailed Hawk	*Buteo jamaicensis*	X	X	X
Red-winged Blackbird	*Agelaius phoeniceus*	X	X	X
Rough-legged Hawk	*Buteo lagopus*	X	X	
Ruby-crowned Kinglet	*Regulus calendula*		X	
Sandhill Crane	*Grus canadensis*		X	
Savannah Sparrow	*Passerculus sandwichensis*		X	

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Say's Phoebe	*Sayornis saya*	X	X	X
Song Sparrow	*Melospiza melodia*		X	X
Spotted Towhee	*Pipilo maculatus*		X	X
Swainson's Hawk	*Buteo swainsoni*		X	
Townsend's Solitare	*Myadestes townsendi*		X	
Tree Swallow	*Tachycineta bicolor*		X	
Turkey Vulture	*Cathartes aura*	X	X	
Vesper Sparrow	*Pooecetes gramineus*	X	X	X
Western Kingbird	*Tyrannus verticalis*	X	X	X
Western Meadowlark	*Sturnella neglecta*	X	X	X
Western Wood Peewee	*Contopus sordidulus*			X
Wilson's Snipe	*Gallinago delicata*		X	X
Wilson's Warbler	*Wilsonia pusilla*	X		
Yellow-rumped Warbler	*Dendroica coronata*	X		
MAMMALS				
Big brown bat	*Eptesicus fuscus*		X	X
Black-tailed prairie dog[a]	*Cynomys ludovicianus*	X		
Bobcat	*Felis rufus*			X
Coyote	*Canis latrans*		X	X
Deer mouse	*Peromyscus maniculatus*		X	X
Desert cottontail	*Sylvilagus audubonii*		X	X
Eastern red bat	*Lasiurus borealis*		X	X
Elk	*Cervus canadensis*		X	X
Fringed myotis[b]	*Myotis thysanodes*		X	X
Hoary bat	*Lasiurus cinereus*		X	X
Little brown myotis[b]	*Myotis lucifuaus*		X	X
Masked shrew	*Sorex cinereus*		X	X
Meadow vole	*Microtus pennsylvanicus*		X	X
Mexican woodrat	*Neotoma mexicana*		X	X
Mountain lion	*Puma concolor*			X
Mule deer	*Odocoileus hemionus*		X	X
Myotis bat	*Myotis sp.*		X	X
Prairie vole	*Microtus ochrogaster*		X	X

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Silver-haired bat	*Lasionycteris noctivagans*		X	X
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*		X	
Western harvest mouse	*Reithrodontomys megalotis*		X	X
Western small-footed myotis	*Myotis ciliolabrum*		X	X
White-tailed deer	*Odocoileus virginiana*			X
Yellow-bellied marmot[a]	*Marmota flaviventris*			
REPTILES AND AMPHIBIANS				
Boreal chorus frog	*Pseudacris maculata*		X	X
Bull snake	*Pituophis catenifer*		X	X
Northern leopard frog[b]	*Lithobates pipiens*			X
Tiger salamander	*Ambystoma tigrinum*			X
Western (Prairie) rattlesnake	*Crotalus viridus*	X	X	X
Woodhouse's toad	*Anazyrus woodhousii*		X	X
TERRESTRIAL ARTHROPODS[c]				
Aphrodite fritillary	*Speyeria aphrodite*		X	
Cabbage white	*Pieris rapae*		X	
Checkered white	*Pontia protodice*		X	
Common wood nymph	*Cercyonis pegala*		X	
Dainty sulphur	*Nathalis iole*		X	
Gray hairstreak	*Strymon melinus*		X	
Orange sulphur	*Colias eurytheme*		X	
Western white	*Pontia occidentalis*		X	

[a] Species were observed at a time other than during a survey.

[b] Colorado State Species of Highest Conservation Need, Tier 1, 2015

[c] Terrestrial arthropods were surveyed in 2011 and only at Flatirons Campus.

A prickly pear cactus (*Opuntia* sp.) found at the STM Campus. *Photo by Brent Nelson, NREL 23906*

APPENDIX D.

PLANT COMMUNITIES AT THE STM CAMPUS AND THE FLATIRONS CAMPUS

Vegetation surveys are periodically completed for the STM Campus and the Flatirons Campus, with the most recent surveys occurring at the STM Campus in 2017 and at the Flatirons Campus in 2016. Plant communities and species were identified for each site at that time, and changes from previous surveys are noted below.

STM Plant Communities

Most vegetation at the STM Campus belongs to the grassland community type. Within that association, there are two distinct community types: short grassland on the mesa top and mixed grassland on the mesa slopes and toe areas. Other mapped vegetation communities at the STM Campus include ravine shrubland, tall shrubland, short shrubland, and wetlands. The plant communities are described below and mapped as illustrated in Figure D-1.

Short Grassland

Short grassland is found on the flat top of the mesa. The dominant grass species are blue grama (*Chondrosum gracile*), a native prairie species, and cheatgrass (*Anisantha tectorum*), a noxious weed. Populations of diffuse knapweed (*Acosta diffusa*) and Dalmatian toadflax (*Linaria genistifolia* subsp. *Dalmatica*) are scattered throughout the whole community; these two noxious weeds comprise approximately 1% of the short grassland.

Alyssum (*Alyssum parviflorum*), an introduced species, is the dominant forb. Several species of prickly pear cactus (*Opuntia fragilis, O. macrorhiza, O. phaeacantha, and O. polyacantha*) occur throughout the short grassland on the mesa top, as does hen and chicks (*Echinocereus viridiflorus*) and pincushion cacti (*Coryphantha missouriensis* and *C. vivipara var. vivpara*). Well-draining hillocks often support thick stands of needle-and-thread grass (*Hesperostipa comata*) and yucca (*Yucca glauca*). Some short shrubs such as rubber rabbitbrush (*Chrysothamnus nauseosus subsp.*), chokecherry (*Padus virginiana*), and skunkbrush (*Rhus aromatica* subsp. *Trilobata*) appear infrequently in the short grassland area and concentrate along the rimrock areas. Several large hackberry trees (*Celtis reticulata*) are clustered at the very edge of the mesa top.

Historically, the short grassland on the mesa top was probably dominated by blue grama grass and other short-grass species such as buffalo grass (*Buchloë dactyloides*), intermixed with the other species associations described above. However, the entire mesa top area has become dominated by cheatgrass, an aggressive noxious weed. This weed is changing the appearance and general species composition of the area by apparently outcompeting native plants.

Mixed Grassland

On the STM Campus, the mesa slopes and toe areas also support blue grama and cheatgrass but are dominated by a mixed-grass species association of needle-and-thread grass and western wheatgrass (*Pascopyrum smithii*), with smaller amounts of big bluestem (*Andropogon gerardii*), sideoats grama (*Bouteloua curtipendula*), three-awn (*Aristida purpurea*), and green needlegrass (*Nassella viridula*). As in the short grassland areas, a large number of forbs also found in the mixed grasslands.

A few patches of anomalous vegetation occur within the mixed grasslands where subsurface water appears to be close to the surface. These areas support wide swaths of mat muhly (*Muhlenbergia richardsonis*). One such area is on a south-facing slope, near the eastern property boundary. The other is on a southwest-facing slope of the ravine north of the NREL Education Center, formerly known as the Visitors Center. This area is notable for a large population of poison ivy (*Toxicodendron rydbergii*), which grows in thickets of tall (>3 feet [>1 m]) plants that have a woody, shrub-like growth form. A small number of plains cottonwood (*Populus deltoides*) saplings, skunkbrush, chokecherry, and snowberry occurs in this patch as well.

The mixed-grass areas grade into both the upland and ravine shrublands and contribute most of the understory in these areas. Some mixed-grass areas also blend into disturbed areas, where reclamation species such as crested wheatgrass (*Agropyron cristatum*) and smooth brome (*Bromus inermis*) have been planted and have subsequently spread into the mixed-grass community.

Upland Shrublands

Shrubland habitat occurs along the upper sides of ravines and on the steeper mesa slopes, and it becomes more prominent as elevation increases up to the top of the mesa. The upland shrubland habitat, which excludes the shrublands in the ravine bottoms, comprises tall shrubland and short shrubland communities very similar in overall composition but distinguished by the dominant species.

Tall Shrubland

The tall shrubland areas are defined by stands of mountain mahogany (*Cercocarpus montanus*) that occur along the rim of the mesa, usually where volcanic cap rock is exposed, and on the upper mesa slopes below rimrock areas. The understory, with a large amount of bare soil, is notably sparse throughout this community. Cheatgrass is the most common herbaceous species in these areas, and it is intermixed with needle-and-thread grass, yucca, and many cacti.

Short Shrubland

The short shrublands occur on elevated flat areas amidst the surrounding grasslands, some of which appear to have experienced surficial disturbance in the past. These areas are distinctive because of the dominance of rubber rabbitbrush. The other common location for short shrublands is on the outer slopes of the ravines. Skunkbrush defines these and other short shrublands along the upper portions of the steepest slopes of the mesa. These communities usually grade into the ravine shrublands along the drainage bottoms and the tall shrublands near the top of the mesa slopes. The short shrubland community also has a sparse understory of the same grasses and forbs as the tall-shrub community.

Ravine Shrublands

Ravine shrublands are limited to the lower sides and bottoms of the drainages that cut down through the mesa slopes. These communities support a variety of shrubs such as skunkbrush, chokecherry, and wild plum (*Prunus americana*), which often grow in dense, impassible thickets. A few plains cottonwoods and peachleaf willow (*Salix amygdaloides*) trees occur at the top of the ravine channels and in other portions of the channel where the subsurface water table appears to be relatively high. A diverse herbaceous component is found in these drainages. In one instance near the southeastern boundary, a ravine shrubland grades into an ephemeral drainage at the toe of the mesa. This drainage is vegetated with grassland species and conducts only occasional surface water runoff.

Wetlands

Five very small communities on the STM Campus have been found to support wetland vegetation. These communities have not been examined for the soils and hydrology that would classify them as functioning wetlands; rather, they are noted only for their dominance of wetland vegetation. These are limited to very small areas (less than 0.5 acre [0.2 hectare] in total). One is in a shallow swale at the mouth of the ravine at the southwestern corner of the site boundary where surface water and/or subsurface drainage have created a pocket of saturated soil. Species here include sedges (*Carex* spp.), rushes (*Juncus* spp.), bulrush (*Schoenoplectus* spp.), and peachleaf willow. The second wetland could have formed as a result of

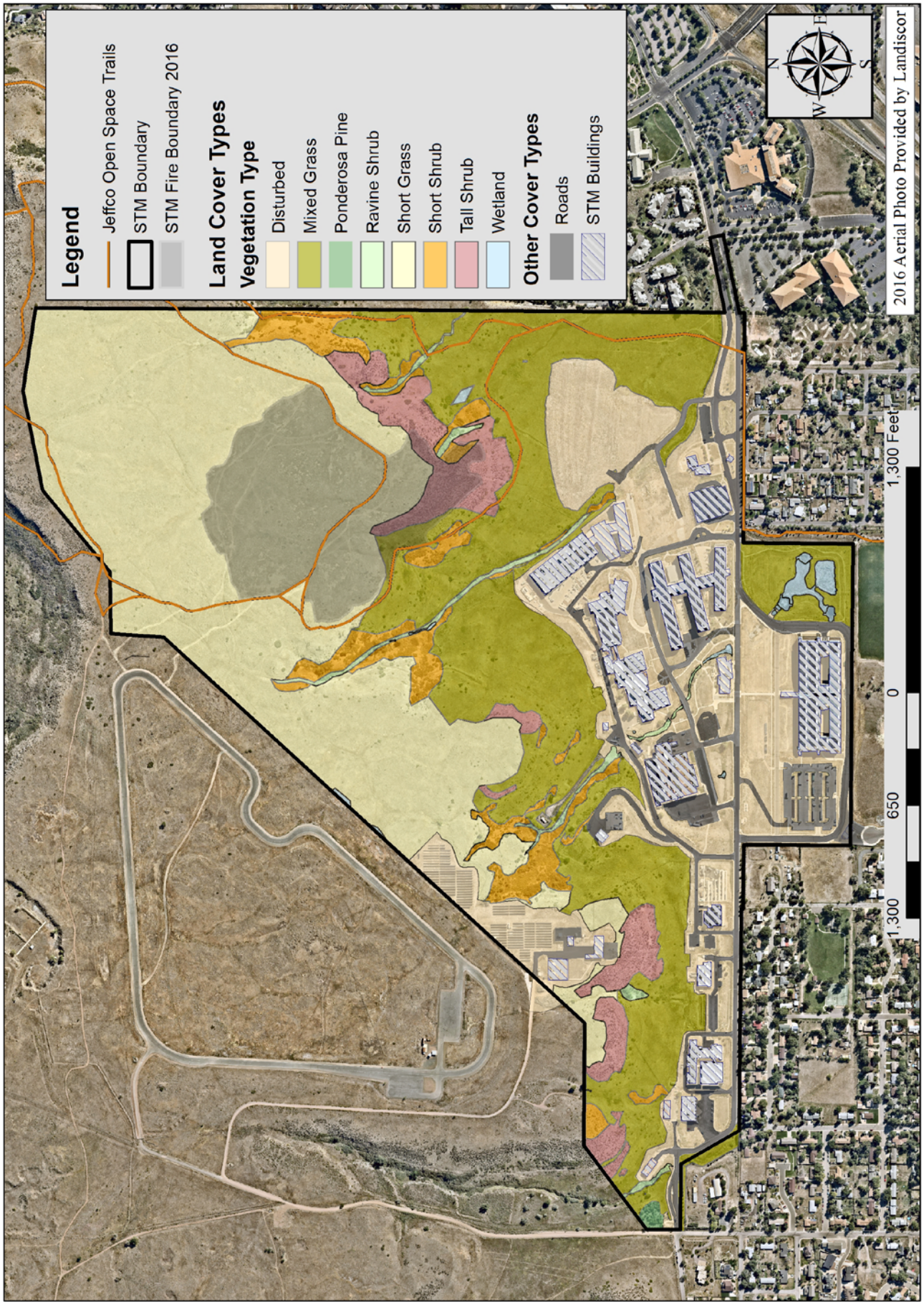


Figure D-1. STM Campus land cover types surveyed in 2017

past construction activities. This linear depression supports wetland vegetation along the central portion of the western site boundary, northeast of the photovoltaic array. Perhaps situated where equipment was once staged, this area appears to hold seasonal water for enough consecutive growing seasons to support some wetland vegetation, including Arctic rush (*Juncus arcticus*), American speedwell (*Veronica americana*), and broadleaf cattail (*Typha latifolia*).

The wetland at the mouth of the ravine may no longer experience the hydrology that originally allowed these plants to establish there. In 2002, this plant community supported populations of cattails that were not observed in the 2011 survey. Three small seeps are located on the hillslope between the NREL Education Center and the public trail on the far eastern boundary of the STM Campus. These seeps are dominated by sedges, rushes, and Canada thistle (*Cirsium arvensis*).

A seventh wetland community that was once observed[12] no longer appears to support wetland vegetation. In 2002, cattail species near an old stock tank in the eastern-most drainage area appeared to have been supported by a pipe coming out of the hillside. Although the stock tank was observed in the 2011 survey, it appears the cattails have not persisted in the intervening years.

Disturbed/Reclaimed

This habitat type comprises all the areas at the site that have experienced surface disturbance to vegetation caused by human activities. These activities mostly occur on the perimeter of the buildings, roads, parking lots, and soil stockpile areas. Most of these areas appear to have been revegetated and support a combination of native grassland plants, planted ornamental revegetation species, and native and introduced weeds.

Flatirons Campus Plant Communities

Most of the vegetation at the Flatirons Campus belongs to the mixed-grass prairie association of the grassland formation. Mixed-grass prairie is defined by the presence of grass species typical of the tallgrass or true prairie such as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and prairie dropseed (*Sporobolus heterolepis*), with species more typical of the short-grass prairie such as blue grama (*Chondrosum gracile*) and buffalo grass (*Buchloë dactyloides*). Intermediate grasses (mid-grasses) such as the needle grasses (*Hesperostipa* and *Nassella* spp.), wheat grasses (*Pascopyron, Agropyron, Elytrigia, Elymus*, and *Thinopyrum* spp.), and blue grasses (*Poa* spp.) are also important constituents of mixed-grass prairie.

The grasslands at the Flatirons Campus fall into the xeric mixed-grassland community type identified and classified primarily on available soils and soil moisture, and reflected in xeric mixed-grassland plant species assemblages.

Several changes in vegetation patterns noted since the Flatirons Campus was previously mapped are discussed below by specific plant community. In addition, the plant communities are described and mapped as illustrated in Figure D-2.

Mixed Grassland

This community is distinguished from the non-native grassland community by the higher cover of native grasses and forbs. Native species typically make up 50%–60% of the vegetative cover. Common grasses in this community include smooth brome, Kentucky bluegrass, Canada bluegrass, big bluestem, little bluestem, switchgrass, and purple three-awn. Common forbs in this community include scurfpea, fringed sage, prairie sage, and hairy golden aster.

Non-Native Grassland

The non-native grassland community is the most common community type at the Flatirons Campus. It is dominated by introduced pasture grasses, including smooth brome, Kentucky bluegrass, and Canada bluegrass. Non-native species make up 65%–90% of the vegetative cover in this community. Commonly observed forb species include alyssum (Alyssum simplex), Canada horseweed (*Conyza canadensis*), fringed sage (*Artemisia frigida*), prairie sage (*Artemisia ludoviciana*), scurfpea (*Psoralidium tenuiflorum*), and hairy golden aster (*Heterotheca villosa*). Native grasses within this community, particularly big bluestem and switchgrass, occur most frequently along roadside depressions, possibly because additional soil moisture from precipitation runoff is captured there.

Disturbed Native Grassland

This community occurs along the northern fence line of the Flatirons Campus. Total vegetative cover in this community ranges from 30% to 70%, and exposed soil in this community consists of coarse gravel. The proximity of this community to machinery and buildings, the abundance of exposed ground, and the gravelly soil texture indicate this area has been significantly disturbed by human activity. However, this community had the highest vegetative cover of native grasses within the Flatirons Campus. This community is dominated by purple three-awn, big bluestem, and switchgrass. Other commonly observed species in this community include non-native grasses such as smooth brome, and ruderal weed species, including annual sunflower (*Helianthus annuus*), prickly lettuce (*Lactuca serriola*), common mullein (*Verbascum thapsus*), and bigbract verbena (*Verbena bracteata*).

12. Plantae Consulting Services. 2000. *Vegetation Survey: NREL National Wind Technology Center*. Boulder, Colorado.

Non-Native Yucca Grassland

This community is very similar in composition to the non-native grassland community, but it is distinguished by the presence of stands of yucca (*Yucca glauca*) shrubs. Yucca typically occurs as scattered individuals throughout the grassland communities at the Flatirons Campus. In the areas identified as non-native yucca grassland, yucca occurs at a higher density than in the surrounding grassland, and the structural change from the surrounding grasslands warrants its inclusion as a separate community. Dominant grass species in this community include downy brome (*Bromus tectorum*), smooth brome, Kentucky bluegrass, and intermediate wheatgrass (*Thinopyrum intermedium*).

Degraded Grassland

The degraded grassland community has been heavily influenced by human disturbance and is dominated by non-native and noxious grass species with minimal native vegetation (typically less than 10%). The dominant species in this community are downy brome and intermediate wheatgrass. Downy brome is a List-C Noxious Weed in Colorado. An area near the southwest corner of the Flatirons Campus contains significant bare soil that is dominated by annual and biennial weed species, including kochia (*Bassia scoparia*), downy brome, and common sunflower. The soil in this area has a distinctive red color that is visible in recent aerial imagery. The degraded grassland community along the western boundary of the Flatirons Campus is possibly influenced by historical and ongoing disturbance that may originate from off-site activities.

Ponderosa Pine Woodland

This community occurs along a granite outcrop located in the northwestern corner of the Flatirons Campus. Dominant tree and shrub species include ponderosa pine (*Pinus ponderosa*), skunkbrush sumac (*Rhus trilobata*), wax currant (*Ribes cereum*), and wild plum (*Prunus americana*). Understory vegetation consists of native and non-native grass and forb species. Common species include smooth brome, crested wheatgrass (*Agropyron cristatum*), junegrass (*Koeleria macrantha*), sulfur cinquefoil (*Potentilla recta*), golden banner (*Thermopsis rhombifolia*), harebell (*Campanula rotundifolia*), and James' nailwort (*Paronychia jamesii*).

Mixed Shrubland

The mixed shrubland community occurs on the southeastern end of the same granite outcrop that supports the ponderosa pine woodland. The southeastern end of this outcrop is lower and less exposed than where the ponderosa pine woodland occurs. Dominant shrub species include wax currant, skunkbrush sumac, chokecherry (*Prunus virginiana*), and western serviceberry (*Amelanchier alnifolia*). This community supports higher cover and diversity of native grasses and forbs than the surrounding non-native grassland community. Common grasses in this community include smooth brome, Kentucky bluegrass, big bluestem, junegrass, and sideoats grama (*Bouteloua curtipendula*). Common forbs include scurfpea, prairie sage, golden banner, hairy golden aster, and sulphur flower (*Eriogonum umbellatum*). An isolated group of hawthorn (*Crataegus erthyropoda*) shrubs occurs along the western site boundary within the Flatirons Campus site boundary. These trees are at the top of the slope and occur directly east of an active area of construction disturbance that is outside the Flatirons Campus boundary.

Palustrine Emergent Wetland

Six wetlands were identified at the Flatirons Campus that fall into the palustrine emergent category.[13] Dominant species in this community type include broadleaf cattail (*Typha latifolia*), Arctic rush (*Juncus arcticus*), common spikerush (*Eleocharis palustris*), and Nebraska sedge (*Carex nebrascensis*). Other commonly observed species include foxtail barley (*Hordeum jubatum*), Torrey's rush (*Juncus torreyi*), cloaked bulrush (*Scirpus pallidus*), and willowherb (*Epilobium*) species. Patches of smooth brome, Kentucky bluegrass, big bluestem, and western wheatgrass (*Pasocpyrum smithii*) occur on the fringes of these wetland communities.

A large palustrine emergent wetland occurs south of the solar array in Row 1 of the array. The southernmost road separates this large wetland from a second smaller wetland along the southern fence line of the Flatirons Campus. These wetlands appear to be hydrologically connected and supported by seepage from a reservoir south of the property boundary. Capture of surface water runoff may provide additional hydrology to these wetlands. The large wetland north of the road was previously identified by one consultant[14]; however, another consultant[15] mapped the area as "mixed mesic grassland" dominated by big bluestem. Hydrological support has evidently increased since 2011, as the area was dominated by obligate wetland species and surface water was present throughout the area during the 2016 field surveys.

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13. Cowardin, Lewis M., Virginia Carter, Edward T. LaRoe, and Francis C. Golet. 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. Washington, D.C.

14. Plantae Consulting Services. 2000. *Vegetation Survey: NREL National Wind Technology Center*. Boulder, CO.

15. Walsh Environmental Scientists and Engineers. 2011. *2010-2011 Vegetation and Wildlife Surveys at the National Renewable Energy Laboratory National Wind Technology Center, Jefferson County, CO*. Prepared for the National Renewable Energy Laboratory. Golden, CO.

A second large palustrine emergent wetland occurs in a seasonal pond southwest of the ponderosa pine woodland community. A consulting firm[12] indicated that wetlands at this location depend on an elevated spring and early summer water table to support the wetland community. Standing water was observed in the pond during both of the 2016 field surveys. Dominant species in this wetland are common spikerush and broadleaf cattail. In the uplands adjacent to this wetland community, Canada bluegrass is the dominant grass species. Canada thistle (*Cirsium arvense*) and common mullein, both noxious weeds, were abundant on the west-facing slope above the pond.

A third large palustrine emergent wetland occurs south of the solar array in Row 3 of the array. This wetland consists of a large stand of cattails (*Typha* spp.) and foxtail barley surrounded by sandbar willow (*Salix exigua*) and plains cottonwood (*Populus deltoides*) trees.

Two small palustrine emergent wetlands occur on slopes along the northern boundary of the Flatirons Campus. The first palustrine emergent wetland is in the northwestern corner of the Flatirons Campus, and the second occurs along the northern fence line, adjacent to the parking lot of Building 251. Dominant species in the westernmost wetland are Nebraska sedge and Arctic rush. Prairie cordgrass and Arctic rush are dominant in the easternmost wetland. These wetlands occur on gentle slopes and appear to be supported by groundwater seeps. Both these wetlands were previously identified and mapped.

Headwater-Riparian Emergent Wetland

Headwater or riparian emergent wetland communities occur within the two prominent drainages in the eastern half of the Flatirons Campus (Figure 7), both of which show evidence of intermittent flow. The northernmost drainage is a tributary to Coal Creek, and the southern drainage is a tributary to Rock Creek. Dominant species within these wetlands include Arctic rush, foxtail barley, Nebraska sedge, and prairie cordgrass (*Spartina pectinata*). Significant patches of Canada thistle, bull thistle (*Cirsium vulgare*), and common teasel (*Dipsacus fullonum*), all List-B noxious weeds, occur within the northernmost drainage. Other observed species include shortbeak sedge (*Carex brevior*), swordleaf rush (*Juncus ensifolius*), longstyle rush (*Juncus longistylis*), Torrey's rush, common spikerush, and switchgrass. Occasional plains cottonwood trees and sandbar willow shrubs occur along these drainages.

Disturbed—Non-Habitat

These cover types reflect surface disturbance that is due to human activities on the site. These areas include roadsides, pad sites, parking lot perimeters, construction sites, and storage areas. Some of these areas have been revegetated and now include a combination of species from surrounding natural plant communities, reclamation species, and adventive (non-native) or ruderal (native or adventive, disturbance colonizer) species. Dominant species noted include smooth brome cheatgrass. (These areas are not specifically called out in Figure 7.)

Ornamental Trees/Shrubs

Disturbed areas around buildings have been planted with a combination of native and ornamental trees and shrubs. Planted trees include multiple species of junipers (*Sabina* spp.) and pines (*Pinus* spp.), interspersed with ornamental deciduous trees. Shrubs in these areas are mainly chokecherry (*Padus virginiana*) and rose (*Rosa* spp.) bushes. (These areas are not specifically called out in Figure 7.)

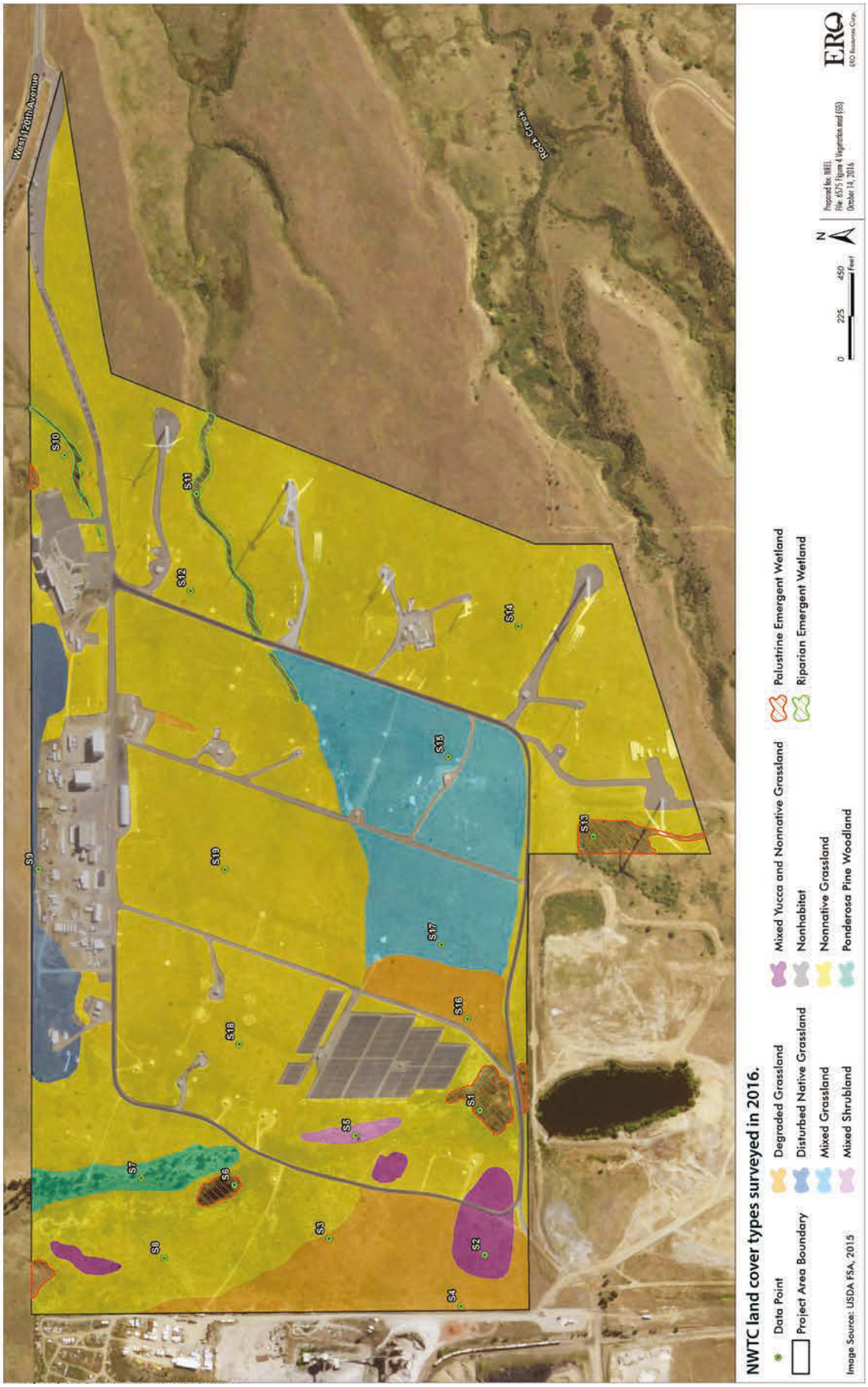

Figure D-2. Flatirons Campus land cover types surveyed in 2016

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