



ENVIRONMENTAL PERFORMANCE REPORT 2017

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



Cover Photo: In late June, a doe found a shady spot just outside the Science and Technology Facility to deliver twin fawns, an event witnessed from a distance by several staff members. A short time later, one of the fawns was already standing. *Photo by Bryan Bechtold, NREL 50156*

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NREL
Environmental
Performance
Report 2017

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NOMENCLATURE

AST	Aboveground Storage Tank	GHG	Greenhouse Gas
CCR	Colorado Code of Regulations	IBRF	Integrated Biorefinery Facility
CDLE	Colorado Department of Labor and Employment	ISO	International Organization for Standardization
CDPHE	Colorado Department of Public Health and Environment	JSF	Joyce Street Facility
CFR	Code of Federal Regulations	MBTA	Migratory Bird Treaty Act
CGI	Controllable Grid Interface	mrem	Millirem
CO₂	Carbon Dioxide	MT	Metric tons
CoMET	Composites Manufacturing Education and Technology	NEPA	National Environmental Policy Act
CRS	Colorado Revised Statute	NREL	National Renewable Energy Laboratory
CWA	Clean Water Act	NWTC	National Wind Technology Center
DERTF	Distributed Energy Resources Test Facility	ODS	Ozone Depleting Substances
DOE	U.S. Department of Energy	OTF	Outdoor Test Facility
DOE Order	Department of Energy Order	RFHP	Renewable Fuel Heating Plant
DOPS	Division of Oil and Public Safety of the Colorado Department of Labor and Employment	RSF	Research Support Facility
DWOP	Denver West Office Park	S&TF	Science & Technology Facility
EA	Environmental Assessment	SERF	Solar Energy Research Facility
EMS	Environmental Management System	SPCC	Spill Prevention Control and Countermeasures
EPA	U.S. Environmental Protection Agency	SRRL	Solar Radiation Research Laboratory
EPCRA	Emergency Planning and Community Right-to-Know Act	STL	Structural Testing Laboratory
EPEAT	Electronic Product Environmental Assessment Tool	STM	South Table Mountain
ESA	Endangered Species Act	TTF	Thermal Test Facility
EO	Executive Order	USACE	U.S. Army Corps of Engineers
ESIF	Energy Systems Integration Facility	VTIF	Vehicle Testing and Integration Facility
FTLB	Field Test Laboratory Building		
FY	Fiscal Year		



EXECUTIVE SUMMARY

Blue flax (*Linum lewisii*) growing in the South Table Mountain site main detention basin is one of many wildflower species that can be observed in the basin and throughout the site. *Photo by Dennis Schroeder, NREL 45386*

Purpose

The National Renewable Energy Laboratory's (NREL's) Environmental Performance Report provides a description of the laboratory's environmental management activities in 2017, including information on environmental and sustainability performance, environmental compliance activities and status, and environmental protection programs, highlights, and successes.

The purpose of this report is to ensure that 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. This 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

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

Each year, the laboratory sets measurable goals for environmental improvement through the NREL Environmental Management System planning process. Goals are also established through the Performance Evaluation and Measurement Plan and the Site Sustainability Plan. Progress of all goals is tracked throughout the year using an online software tracking system. A summary is prepared annually for

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 between 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 led to numerous success stories from across the laboratory. NREL's two sites, the 327-acre (132 hectares)

South Table Mountain main site in Golden, Colorado, and the 305-acre (124 hectares) National Wind Technology Center 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.



Deer grazing near a test photovoltaic array at the South Table Mountain site. Photo by Dennis Schroeder, NREL 45449

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 2017 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:

- Achieved short-term internal environmental and sustainability goals, and made progress toward long-term goals (for more details, see section 2, Environmental Management System and Pollution Prevention, and section 3, Sustainability)
- Received several awards and recognitions for environmental and sustainability accomplishments (see sidebar on page 8)
- Recertified to International Organization for Standardization 14001:2015 for environmental management systems, as verified by a team of external auditors
- Continued to make progress on identifying and implementing solutions to operational vulnerabilities that could result from climate change
- Installed a thermosyphon on the high performance computing data center in the Energy Systems Integration Facility at the South Table Mountain site, which significantly reduced water consumption while maintaining a world-class power usage effectiveness rating of 1.03. Power Usage Effectiveness (PUE) is the ratio of total amount of energy used by a computer data center to the energy delivered to computing equipment. An ideal PUE is 1.0.
- Decontaminated and properly disposed of equipment, such as test chambers, exhaust hoods, and glove boxes, from several individual laboratory spaces that were undergoing renovation
- Enhanced spill control preparedness training through mapping of key spill control points based on proximity to site drainage features, ease of access, and ease with which sorbents and containment structures can be deployed
- Continued to provide support to DOE in identifying potential environmental impacts related to renewable energy efforts that support DOE's mission
- Continued acoustical bat monitoring at the National Wind Technology Center



An especially large number of Painted Lady butterflies (*Vanessa cardui*) were seen in September 2017 across the STM site, most commonly on flowering Rabbitbrush (*Ericameria nauseosa*). Photo by Werner Slocum, NREL 50278

- Conducted wildlife surveys at the South Table Mountain site; highlights included documentation of the Northern Pygmy Owl (*Glaucidium californicum*), which had not previously been recorded
- Installed four nest structures for Barn Swallows (*Hirundo rustica*) at the National Wind Technology Center
- Delayed removal of a metal shed so that an active bee hive within the shed could be removed and relocated at a time of year that would not impact the viability of the colony
- Successfully used raptor predator call recordings and visible decoys to deter roosting pigeons at the South Table Mountain site parking garage structure
- Hosted and participated in a symposium at the Northern Wildlife Society on renewable energy and impacts to wildlife
- Hosted a local Audubon group at the South Table Mountain site to tour the facility and provide information regarding bird-friendly building design and retrofits.

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. 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.

The laboratory continued its excellent record of environmental compliance in 2017. 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.

Environmental Management Programs

The laboratory continued to improve its environmental management and performance in 2017, 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 preventing unallowable sanitary sewer system discharges

Prestigious Environmental Sustainability Awards Received

NREL received the following important recognitions in 2017 for its environmental and sustainability accomplishments, including:

- Three Star Electronic Product Environmental Assessment Tool Purchases Award from the Green Electronics Council for excellence in the procurement of high-performance sustainable electronics
- Colorado Environmental Leadership Program Gold-Level Leader Award for exceeding regulatory requirements and for continued partnership with the Colorado Department of Public Health and Environment since 2004
- DOE Honorable Mention for NREL's nomination for the 2017 Presidential Migratory Bird Federal Stewardship Award, which recognizes migratory bird conservation efforts at federal facilities and projects involving a federal partnership.

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

The laboratory's environmental management system has been ISO 14001 certified since 2011. The initial certification was for the 2004 version of the standard, and during 2017 the management system was recertified to the current 2015 version. A team of external auditors conducted an independent assessment of the policies, procedures, tools, and roles and responsibilities used in environmental management. The assessment verified that the laboratory continues to meet the requirements of ISO 14001, demonstrating the laboratory's commitment to environmental stewardship.

- Hazardous materials and waste management including pollution prevention; spill response; proper storage, use, and disposal of hazardous chemicals and materials; planning; permitting; and reporting regarding 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.



1 INTRODUCTION

The rotor from the U.S. Department of Energy's 1.5 megawatt wind turbine at the National Wind Technology Center is removed to allow installation of a new gearbox to undergo reliability testing.

Photo by Brad King, NREL 49520

1.1 Purpose

This report presents a summary of the National Renewable Energy Laboratory's (NREL's) environmental management activities in 2017, including:

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

This report incorporates the U.S. Department of Energy's (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*.

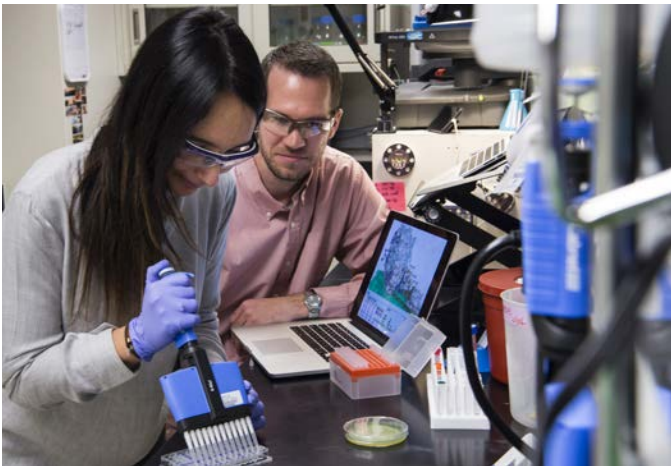
1.2 Our Mission

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.

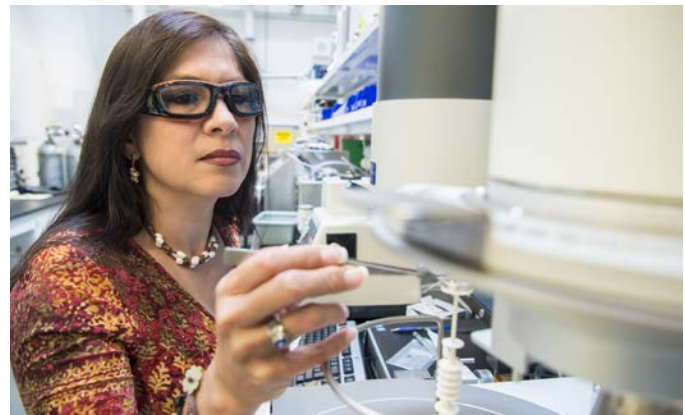
- **Advanced Manufacturing** – Scientific and engineering research at NREL focuses on reducing energy requirements associated with the most energy-intensive manufacturing industries and accelerating those innovations to commercialization of next-generation technologies and processes.
- **Bioenergy**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



NREL staff prepares samples for research in improving enzyme performance for breaking down plant matter into renewable fuels and products. *Photo by Dennis Schroeder, NREL 49146*

- **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 conducts research across the entire spectrum—from 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, scientific data management, visualization, and informatics. NREL is also 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 concentrated solar power technologies. Concentrated 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 the South Table Mountain site’s Energy Systems Integration Facility and at the National Wind Technology Center collaborates 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 on developing, integrating, and demonstrating hydrogen production and delivery, hydrogen storage, and fuel cell technologies for transportation, stationary, and portable applications.



An NREL researcher works with a differential scanning calorimeter to characterize thermal fluids at high temperatures for corrosion-resistant metal coatings used in concentrating solar power equipment. *Photo by Dennis Schroeder, NREL 45088*

- **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** – Photovoltaic cells enable the direct conversion of sunlight into electricity using solid-state materials. 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 toolkits to assist water power sector businesses in navigating hydropower regulations.



NREL sponsored and hosted the “Workshop on the Present and Future of Energy Storage” at which NREL researchers collaborated with attendees on strategies, developments, breakthroughs, and challenges associated with energy storage. *Photo by Dennis Schroeder, NREL 49377*



Crews work to install the first power-to-gas system in the U.S. at the STM site. Southern California Gas partnered with NREL on the project, which takes excess electricity and converts it to hydrogen, which can be used, stored or combined with carbon dioxide to produce renewable natural gas. *Photo by Werner Slocum, NREL 47256*

- **Wind energy** – From conceptualizing taller turbines capable of greater energy capture to assessing the United States’ offshore wind energy needs and potential, the National Wind Technology Center drives wind industry acceleration. Facilities at the National Wind Technology Center 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.

1.3 Site and Facility Description

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

- National Wind Technology Center (NWTC)
- South Table Mountain (STM)
- Denver West Office Park
- Joyce Street Facility
- Renewable Fuels and Lubricants Research Laboratory.

The STM site and the NWTC are the primary locations for NREL research operations. The Denver West Office Park is leased space used primarily for administrative functions and limited research activities. The leased Joyce Street Facility space is primarily used for storage. 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 for the geographic region of NREL operations is classified as semi-arid, 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 of 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, reaching 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 Rocky Mountains and the Front Range. The highest average snowfall typically occurs in March, during which time at least one heavy snowstorm of between 6 to 10 inches (15 to 25 cm) may occur.

The solar radiation (sunlight energy) of the region is excellent for outdoor research and testing of 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 Site

The STM site is the main research center for NREL—nearly 80% of the laboratory’s staff has offices and laboratories there. The STM site 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 site is a roughly triangular parcel of land occupying portions of the top, sides, and lower south-facing slopes of South Table Mountain, a mesa that stands approximately 492 feet (150 meters [m]) above the adjacent lowlands. South Table Mountain is composed of sedimentary rocks below a basalt lava cap, which is quite resistant to erosion.

The STM site is a 327-acre (132 hectares) area predominantly bordered by open grassland zoned for recreation and light commercial activity. Portions of the community of Pleasant View are located immediately to the south and west. Pleasant View has constructed a recreational park immediately south of the STM site. Offices, shops, and a tree nursery owned by the Colorado State Forest Service are located at the far western edge. Undeveloped state land and a Colorado State Highway Patrol pursuit driver-training track are located along the northwestern boundary of the STM site 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 site (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 more 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. Below the lava caprock, the sedimentary rocks are part of the Denver Formation that 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 site occurs primarily in the weathered and fractured silts and sands of the Denver Formation. There may also be some groundwater in the form of perched aquifers 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.



NREL's South Table Mountain Site. Photo by Dennis Schroeder, NREL 30709

The soil covering the top of South Table Mountain is lava 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 a 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. It 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—cobble 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). While there is no permanent stream flow on the STM site, occasional flow from extended periods of precipitation, usually during the late winter and early spring, is found in the drainage channels, with seasonal springs evident along some of the mesa slopes. The mesa top features one seep that is often active throughout much of the year, but the water infiltrates and evaporates quickly during the dry season.

Vegetation

Two primary vegetation types are present on the STM site: grasslands and shrublands. The most common plant communities on the STM site are mixed grasslands, comprising 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 occur on the STM site: mountain mahogany shrublands, found on the shallow soils of the mesa, and upland shrublands, occurring in drainages lacking active channels as well as drainages with associated wetlands. Field surveys have identified limited wetland and riparian areas along drainages. The wetland communities identified on the STM site 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 acres (0.3 hectares). Riparian shrub communities also occur adjacent to the emergent wetlands. (For more details, see Appendix D, Plant Communities at the STM site and the NWTC.)

Wildlife

Several comprehensive wildlife surveys have been conducted on the site, starting with the original study in 1987. Numerous mammals, and several types of amphibians and reptiles, have been identified during the surveys. More than 75 species of birds and a number of raptor species have also been recorded at or above the STM site by formal wildlife surveys and through employee observations. (For more details, see section 9.1, Wildlife Management, and Appendix C, Wildlife Species Observed at the STM site and the NWTC).



A Common Loon (*Gavia immer*) made an unexpected landing at the NWTC on a foggy morning in November. A wildlife rehabilitation organization took the bird to a nearby pond to resume its journey south for the winter. *Photo by Garth Johnson, NREL 50078*

National Wind Technology Center

The NWTC is the main facility for NREL's wind turbine technology research. Located on the Jefferson-Boulder County border just east of the foothills of the Rocky Mountains, the NWTC has abundant wind resources that are critical for the variety of projects conducted at the site. The NWTC is located near the intersection of Highways 93 and 128, between Boulder and Golden, and is approximately 15 miles (24.2 km) north of the STM site.

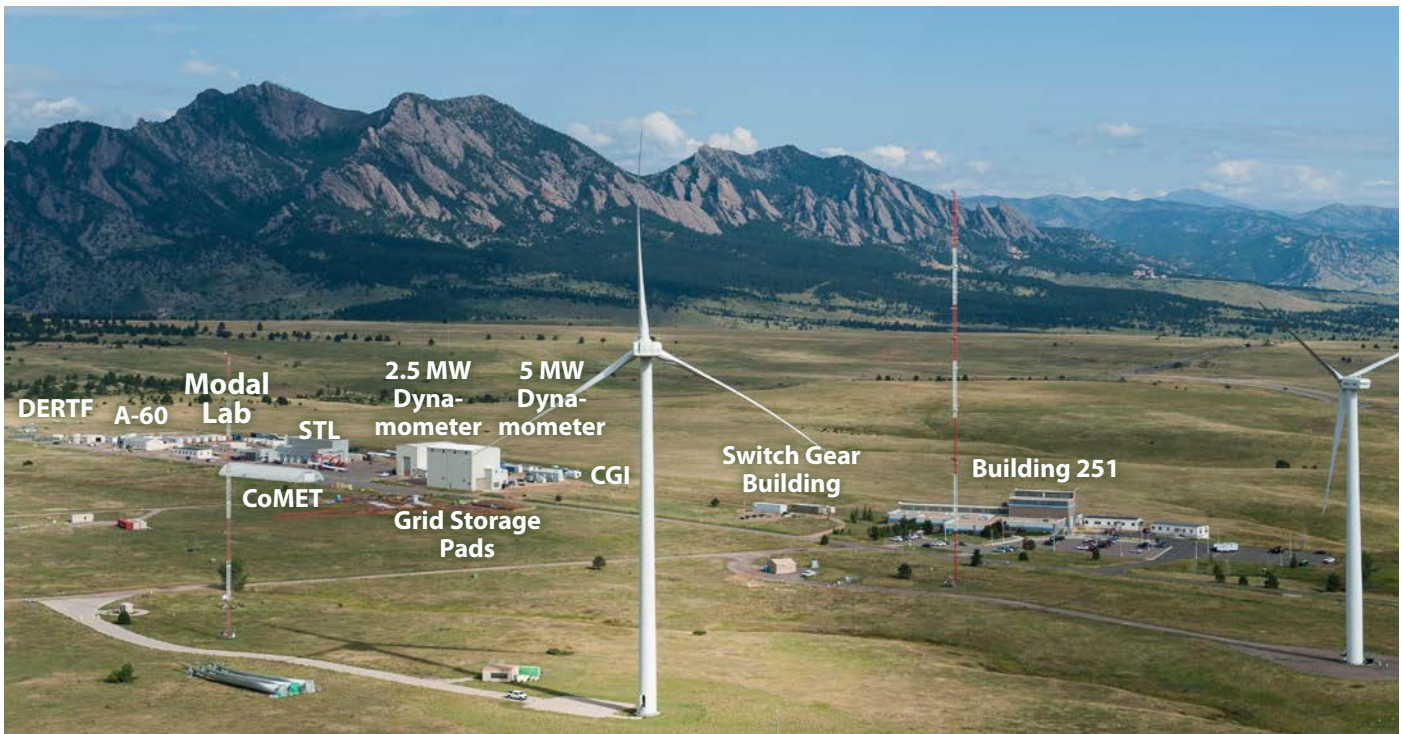
Land Use

The NWTC occupies a 305-acre (124 hectares) area surrounded by open space, grazing, and industrial land uses. The Rocky Flats National Wildlife Refuge borders the NWTC 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 site. 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 NWTC to the north; State Highway 128 lies to the north of that open space.

Geology, Soils, and Hydrogeology

The NWTC is located on a plain formed by stream deposits. The uppermost geological layer 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 rock 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

1. EG&G Rocky Flats, Inc. (1992). Rocky Flats Plant Site Environmental Report, January Through December 1992. Golden, Colorado.



NREL's National Wind Technology Center. Photo by Dennis Schroeder, NREL 30766

The NWTC 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 subsoil dominated by clay.

Surface Water

The area surrounding the NWTC 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 NWTC. 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 NWTC.

The majority of the NWTC drains into a tributary to Rock Creek. Some of the northern portions of the site drain into Coal Creek or its tributaries.

Vegetation

The NWTC is located in the transition area between the Great Plains and the Rocky Mountains.² This location results in a flora that contains elements from both mountain and prairie ecosystems, and associations that represent residual tallgrass prairie, shortgrass plains, ponderosa pine woodland, and foothill ravine flora.³

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

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

Wildlife

Although the site was heavily grazed by cattle prior to 1975, surveys conducted since that time identified several species of mammals that utilize vegetation and other habitat that exists at the NWTC. Included among these are mule deer, coyotes, white-tailed jackrabbits, and thirteen-lined ground squirrels. Amphibians and reptiles (including the prairie rattlesnake) and numerous species of birds and raptors have been documented in surveys conducted since 1992. (For more details, see Appendix C, Wildlife Species Observed at the STM site and the NWTC.)

2. Plantae Consulting Services. (2000). Vegetation Survey, NREL National Wind Technology Center. Boulder, Colorado.

3. ERO. (2016). 2016 Wildlife and Vegetation Monitoring Report, National Wind Technology Center. Jefferson County, Colorado.



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

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 site. In addition to office spaces, activities at the Denver West Office Park include low-risk research related to fuel and battery characterization, thermal analyses of vehicle cooling loops, vehicle electrical systems analysis, and photo-electrochemical hydrogen production.

Joyce Street Facility

The Joyce Street Facility is located in a commercial area surrounded by agricultural land, residential neighborhoods, and small businesses. It is currently used by NREL primarily as warehouse space; there are no staff offices at this location. The Joyce Street Facility is located at 6800 Joyce Street, about 5.5 miles (8.9 km) north of Denver West Office Park and the STM site.



Joyce Street Facility (leased area indicated in blue). Photo courtesy of Google Earth.

Renewable Fuel 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 located at 1900 31st Street in Denver, approximately 12 miles (20 km) east of the STM site. The District's Shops and Operations Center facility occupies approximately 22 acres (9 hectares) of land 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 site 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 on site or in the immediate vicinity. There are trees and shrubs lining the South Platte River adjacent to the site's southern, eastern, and northeastern borders.



A bus prepares to undergo testing at the Renewable Fuel and Lubricants Laboratory. Photo by John Ireland, NREL 17948



2 ENVIRONMENTAL MANAGEMENT SYSTEM AND POLLUTION PREVENTION

Aerial view of the Research Support Facility, including rooftop solar panels. *Photo by Dennis Schroeder, NREL 21794*

NREL's Environmental Management System (EMS) provides effective environmental stewardship and minimizes the environmental impacts of laboratory activities and operations. The EMS is a framework of policies, procedures, and programs that integrates environmental protection into daily work practices. The laboratory's EMS efforts include:

- Protection and enhancement of vegetation, wildlife, and natural resources of the laboratory sites
- Pollution prevention
- Compliance with environmental requirements
- Encouragement of continual improvement in environmental protection and sustainability performance.

The laboratory strives to continually minimize waste and prevent pollution, thus reducing its environmental footprint. Pollution prevention is implemented through the laboratory's EMS, the Hazard Identification and Control program, 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
 - Continual improvement of environmental and sustainability performance.
- **Environmental aspects** – 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 by the identified significant aspects. NREL also utilizes 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 (EOs), and DOE orders.



Figure 1. NREL’s continual improvement cycle

- **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 more details, see section 2.3.)

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 workers are competent on the basis of education, training, or experience, and implements a robust environment, health, and safety training program.
- **Communication** – NREL provides a number of 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 environmentally related 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 record control** – Policies and procedures ensure that the current, correct versions of documents are available for use and that records are maintained to meet requirements.

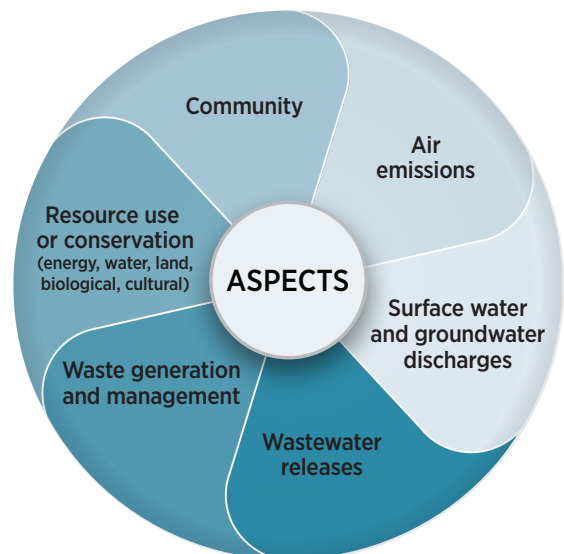


Figure 2. NREL’s environmental aspects

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 more details, see section 2.4.)

Management Review

- **Management Review** – NREL's management review 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. NREL fulfills this commitment by implementing a variety of controls to reduce the potential environmental impacts of laboratory operations. These operations include 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

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 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.

prevent pollution, and formal pollution prevention assessments are conducted periodically to identify opportunities to reduce pollution and improve program effectiveness. While the majority of NREL's environmental management programs were established to meet compliance requirements, many of these programs go beyond compliance requirements, continually improving environmental performance.

2.3 Performance Indicators and Progress

Each year measurable goals for environmental improvement are developed. Goals are identified in the following documents:

- **Performance Evaluation and Measurement Plan** – The Performance Evaluation and Measurement 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** – NREL develops a Site Sustainability Plan each year to establish sustainability performance commitments and document activities that support the requirements of EO 13693, *Planning for Sustainability in the Next Decade*. Results of 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 2017 are described in Table 1.



NREL encourages its employees to use alternative transportation methods by providing public transportation passes, shuttle bus connections to local transit stations, vanpools, ride-sharing information, and numerous bike racks. Such practices contribute toward management of NREL's environmental aspects, in this case, reducing air emissions. *Photo by Dennis Schroeder, NREL 30466*

Table 1. 2017 Environmental Goals and Achievements

2017 Goals	2017 Examples	Goal Met?
<p>Develop a final plan for Section 106 Programmatic Agreement with the Colorado State Historic Preservation Office</p>	<p>Completed a project plan identifying the general process, requirements, and milestones to develop the Programmatic Agreement</p>	<p>Yes</p>
<p>Deliver an Efficient and Effective Environmental Management Program</p>	<p>Identified risks and modified practices including:</p> <ul style="list-style-type: none"> • Infrastructure and research equipment replacement process enhancements • Site Operations backflow prevention recordkeeping improvements • Continued spill response training for shuttle drivers • Assisted Site Operations with mentoring contractors to address stormwater deficiencies <p>Monitored proposed and final regulations and adherence to requirements including:</p> <ul style="list-style-type: none"> • Hazardous Waste Generator Improvement Rule • Protection of Stratospheric Ozone • EPA air quality operating standards for small boilers • 2017 EPA Construction Stormwater General Permit <p>Completed inspections and assessments including:</p> <ul style="list-style-type: none"> • Air inspection by Jefferson County • Aboveground storage tank inspection by Department of Public Safety • Internal assessment, Cultural Resources • Internal assessment, Pest Management • Independent assessment, Air Quality • Conservation area early summer and fall inspections • Wildlife and vegetation surveys <p>Took actions to protect and enhance habitat and the natural environment including:</p> <ul style="list-style-type: none"> • Installed six new nest boxes for woodpeckers and Barn Swallows • Revised the site seed mixes to include pollinator plant species • Delayed activities at the High Flux Solar Furnace facility to protect a resident bee hive • Provided snake handling and safety training to Security staff • Restricted access to areas to protect fledgling birds <p>Collaborated to integrate environmental considerations in project planning including:</p> <ul style="list-style-type: none"> • S&TF clean room and waste neutralization • NWTC electrical upgrades • IBRF spill planning 	<p>Yes</p>

2017 Goals	2017 Examples	Goal Met?
<p>Ensure procedures and controls are in place and implemented to comply with environmental regulatory requirements</p>	<p>Staff attended trainings and webinars to continue to sharpen skills and maintain awareness of emerging requirements and best practices</p> <p>Actively managed noxious weeds</p> <p>Tracked criteria air pollutants and greenhouse gases to evaluate permitting requirements (annual air emission inventory report and <i>Mandatory Reporting Rule</i> report)</p> <p>Completed inspections of all STM site and NWTC petroleum drums and storage areas to verify conformance to spill prevention, control, and countermeasure requirements</p> <p>Provided annual Spill Response and Awareness training to NREL and contracted shuttle drivers</p>	<p>Yes</p>
<p>Maintain and implement continuous improvement of ISO 14001 management system</p>	<p>Successfully achieved ISO14001:2015 upgrade certification as evidence of management system compliance to international standards.</p> <p>Implemented all corrective actions from the prior year's ISO audit.</p>	<p>Yes</p>

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 assessment** – Internal assessments are performed regularly to evaluate consistency of the EMS with the ISO 14001 standard, legal, and other requirements.
- **External assessment** – 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 necessary based on the results of each assessment performed.

The following assessment activities took place in 2017 and have allowed NREL to enhance program effectiveness and make substantial environmental performance improvements:

- **Internal assessments** – Three internal assessments of processes were completed for the following topics: air quality management, cultural resources management, and pesticide



Seats of a historical amphitheater at the STM site. An internal assessment of the laboratory’s management of cultural resources identified three opportunities for improvement. *Photo by David Parsons, NREL 06922*

management. Each assessment involved interviews with staff and reviews of relevant procedures and records. The air quality management assessment resulted in no non-conformities or opportunities for improvement. Three opportunities for improvement, which were identified in the cultural resources management assessment regarding operational planning and control and documented information, have been addressed. The pesticide management assessment resulted in four non-

conformities regarding document control and operational planning and control; actions to address the non-conformities are underway.

- **External assessments** – NREL underwent a recertification assessment to verify conformance to the ISO 14001:2015 standard. The assessment was conducted by a team of external auditors and included visits to a number of the

Benefits of the EMS to NREL

Reduced risk to facility/organizational mission

NREL's Hazard Identification and Control Program incorporates environmental risk assessment. System improvements also support the use of requirements to reduce the risk of non-compliance and potential enforcement actions.

Improved fiscal efficiency and/or 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 *NREL Now* internal newsletter; postings on the NREL intranet; new employee orientation and activity-specific trainings; 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. The *Be the Change* program encourages individuals to suggest changes to improve the environment and sustainability of the laboratory.

Integration of environment into organizational culture and operations

NREL strives to maintain a high level of awareness in the laboratory around safety, health, and environmental

responsibilities. This 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 the STM site and the NWTC. 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 National Environmental Policy Act process. NREL takes proactive measures to engage the community with public tours, newsletters, and mailings to neighborhoods surrounding 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.

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 11 system strengths, three non-conformities, and four opportunities for improvement. Corrective actions addressing each of the non-conformities have been completed.

2.5 2017 Awards and Recognition

In 2017, NREL received several awards and recognition of its environmental and sustainability achievements including:

- Green Electronics Council Electronic Product Environmental Assessment Tool (EPEAT) Purchaser Award
- Colorado Environmental Leadership Program Gold-Level Leader
- 2017 Presidential Migratory Bird Federal Stewardship Award – DOE Nomination Honorable Mention.

Green Electronics Council Award

In 2017, NREL received the Three-Star EPEAT Purchaser Award from the Green Electronics Council for 2016 EPEAT purchases. NREL is committed to the purchase of products designated by EPEAT, ENERGY STAR, and the Federal Energy Management Program, wherever feasible, to continue to positively impact the environment through these purchases.



2017 Colorado Environmental Leadership Program event.

Photo courtesy of CELP, NREL 50128

Colorado Environmental Leadership Program Gold-Level Leader

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 between the Colorado Department of Public Health and Environment (CDPHE) and participating private and public Colorado facilities, and is intended to recognize environmental leadership and performance.

In early 2004, NREL was the first laboratory accepted into the program as a Gold-Level Leader and it has maintained this leadership level ever since. As a component of program membership, NREL's voluntary environmental performance goals, described above, further enhance operations and performance at the laboratory. Colorado Environmental Leadership Program recognizes facilities that voluntarily:

- Exceed regulatory requirements
- Implement the EMS (which 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.

Learn more about this voluntary program at the state website:

<https://www.colorado.gov/pacific/cdphe/environmental-leadership-program>.

2017 Presidential Migratory Bird Federal Stewardship Award – DOE Nomination Honorable Mention

In 2017, NREL and the Golden Field Office received an honorable mention from DOE for the 2017 Presidential Migratory Bird Federal Stewardship Award. This award program annually recognizes a single project or action conducted by or in partnership with a federal agency that meets the intent and spirit of Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, by focusing on migratory bird conservation. The laboratory's nomination, entitled *NREL Migratory Bird Conservation Planning and Building Retrofits*, described its comprehensive program for the conservation of migratory birds on its 327-acre STM site and the 305-acre NWTC using a four-pronged approach which included:

1. Development of a Migratory Bird Conservation Plan
2. Requiring nesting bird surveys for projects with potential impacts to birds
3. Incorporating bird friendly design for new facilities, and
4. Retrofitting buildings having impacts to birds from window collisions.

2.6 Integrated Environmental Stewardship in Construction Management

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

Project Planning and Design

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

In 2017, a new structure was designed at the NWTC for roadway deicing material storage. The structure, which will be completed in 2018, will include an adjacent stormwater

detention basin seeded with salt-tolerant and salt-absorbing grasses to filter snowmelt runoff and consequently protect groundwater quality.

Environmentally Responsible Construction Practices

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

Minimizing impacts to wildlife is a consideration for all construction projects. During 2017 this was demonstrated by providing numerous ramps to facilitate egress of mammals that may have entered trenches constructed as part of a large electrical upgrade project at the NWTC.

Benefits of the EMS to the Environment

Improved overall compliance management

NREL maintains a formal process to identify regulations and standards applicable to NREL, including federal laws and regulations, state and local requirements, executive orders, and DOE orders. In addition, compliance with these requirements is regularly reviewed through a variety of 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 identifies 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 program.

Improved air and water quality

The EMS goals relating to the use of alternative energy sources, the use of clean-burning fuels, and the minimization of the quantity of chemicals used on site contribute toward improved air quality. NREL continually strives to protect water quality onsite and offsite through

refinement and implementation of requirements related to the management of runoff, operations, and outdoor storage/use of materials at both temporary construction sites and throughout facility grounds.

Improved hazardous material, hazardous waste, and solid waste management

Hazardous material tracking through the NREL chemical inventory reduces the purchase of new supplies by allowing staff to determine if a needed chemical already exists 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, greatly exceeding DOE goals for waste diversion.

Improved 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 permits needed to operate

Implementation of the EMS provides a mechanism to identify, evaluate, and implement pollution prevention opportunities including waste minimization, product substitution, and process modification. These efforts can reduce the number of regulatory requirements that the laboratory must meet.

2017 Accomplishments And Highlights

- NREL successfully transitioned to the new 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.
- Three internal assessments were completed, covering the following programs: air quality management, cultural resources management, and pesticide management. The air quality management assessment resulted in no non-conformities or opportunities for improvement. Three opportunities for improvement that were identified in the cultural resources management assessment regarding operational planning and control and documented information have been addressed. The pesticide management assessment resulted in four non-conformities regarding document control and operational planning and control; actions to address the non-conformities are underway.



An integrated project team consisting of representatives from various departments within NREL, together with construction contractors, attend a weekly meeting to discuss an electrical upgrade project at the NWTC. *Photo by Genevieve Braus, NREL 50127*



3 SUSTAINABILITY

NREL staff participate in the annual Bike to Work Day event, whose goal is to encourage people to try their bikes as an alternative means of transportation on a consistent basis thereby reducing traffic congestion and improving air quality. *Photo by Dennis Schroeder, NREL 45460*

NREL pursues sustainability in all laboratory operations and strives to minimize the environmental, economic, and social 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 carrying out the mission of 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*, a Site Sustainability Plan is developed each year to report on past performance and set goals for the coming year. These performance goals are integrated with the laboratory's EMS and progress is tracked throughout the year.

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
- Climate change resilience planning
- Measurement and tracking of environmental objectives, targets, and actions
- Awareness and engagement of staff and community members.

Table 2 summarizes DOE's 2017 performance in meeting its sustainability goals at NREL.

Table 2. Sustainability Goals and Performance Summary

DOE Goal	Current Performance	Status
Multiple Categories		
50% Scope 1 & 2 greenhouse gas (GHG) emissions ^a reduction by FY 2025 from a FY 2008 baseline.	95.8% reduction	On Track to Meet Goal
25% Scope 3 GHG emissions ^b reduction by FY 2025 from a FY 2008 baseline.	20.5% reduction	On Track to Meet Goal
Energy Management		
25% energy intensity (British thermal unit per gross square foot) reduction in goal-subject buildings by FY 2025 from a FY 2015 baseline	7.9% reduction	On Track to Meet Goal
Energy Independence and Security Act, Section 432 continuous (4-year cycle) energy and water evaluations	Conducted energy and water audits at the Education Center, East Site Entrance building, Science and Technology Facility, and Shipping and Receiving building	On Track to Meet Goal
Meter all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate	100% of NREL's buildings have energy meters (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		
36% potable water intensity (gallon per gross square foot) reduction by FY 2025 from a FY 2007 baseline	28.9% reduction	On Track to Meet Goal
30% water consumption reduction of industrial, landscaping and agricultural (ILA) water by FY 2025 from a FY 2010 baseline	NREL does not use ILA water	N/A
Waste Management		
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris	63.9% diversion	Target Met
Divert at least 50% of construction and demolition materials and debris	88.7% diversion	Target Met

^a Scope 1 and 2 emissions are defined as follows:

Scope 1 emissions (Direct GHG) – emissions from sources that are owned or controlled by an organization. Examples of 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) – emissions from the consumption of purchased electricity, steam or other sources of energy generated upstream from an organization. Examples of sources at NREL include grid electricity used to power buildings and laboratory experiments.

^b Scope 3 emissions (Other Indirect GHG) – emissions that are a consequence of the operations of an organization but are not directly owned or controlled by the organization. Examples of sources at NREL include fuel use associated with employee commuting and business travel, and waste sent to the landfill.

DOE Goal	Current Performance	Status
Fleet Management		
30% reduction in fleet-wide per-mile GHG emissions reduction by FY 2025 from a FY 2014 baseline	27.5% reduction	On Track to Meet Target
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; maintain 20% reduction thereafter	19% reduction	Did not meet 20% reduction for current year
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter	33.1% increase	Target Met
75% of light-duty vehicle acquisitions must consist of alternative fuel vehicles (AFV)	No light-duty vehicles were acquired	N/A
50% of passenger vehicle acquisitions consist of zero emission or plug-in hybrid electric vehicles by FY 2025	No passenger vehicles were acquired; NREL does not currently have or plan to procure any vehicles classified as passenger vehicles	N/A
Clean & Renewable Energy		
"Clean Energy" requires that the percentage of an agency's total electric and thermal energy accounted for by renewable and alternative energy shall be not less than 25% by FY 2025 and each year thereafter	104% renewable and alternate energy use	On Track to Meet Target
"Renewable Electric Energy" is required to account for not less than 30% of a total agency electric consumption by FY 2025 and each year thereafter	133.2% renewable electric energy consumption	On Track to Meet Target
Green Buildings		
At least 17% (by building count) of existing buildings greater than 5,000 gross square feet to be compliant with the revised Guiding Principles for High-Performance and Sustainable Buildings (HPSB) by FY 2025, with progress to 100% thereafter	33.3% meet HPSB guidelines	On Track to Meet Target
Net Zero Buildings: 1% of the site's existing buildings above 5,000 gross square feet intended to be energy, waste, or water net-zero buildings by FY 2025	Two buildings (11%) of eligible buildings are net zero energy	On Track to Meet Target
Net Zero Buildings: 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 Target

DOE Goal	Current Performance	Status
Green Buildings		
Increase regional and local planning coordination and involvement	<p>Participated in regional events to promote alternative commuting including Bike to Work Day and GoTober</p> <p>Hosted an electric autonomous shuttle demonstration and invited local businesses and municipalities to attend</p> <p>Contributed to the Colorado governor’s Climate Resilience Working Group</p>	Target Met
Acquisition & Procurement		
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred and biobased provisions and clauses are included in 95% of applicable contracts	100% sustainable acquisition and procurement	Target Met
Measures, Funding, & Training		
Annual targets for performance contracting to be implemented in FY 2017 and annually thereafter as part of the planning of section 14 of EO 13693	Continued to utilize other funding options such as renewable energy credit sales and utility rebates	Target Met
Electronic Stewardship		
Purchases – 95% of eligible acquisitions each year are EPEAT-registered products	99.1% EPEAT-registered products	Target Met
Power management – 100% of eligible PCs, laptops, and monitors have power management enabled	100% power management enabled	Target Met
Automatic duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled	100% automatic duplexing enabled	Target Met
End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year	100% electronics reused or recycled	Target Met
Data Center Efficiency – Establish a power usage effectiveness (PUE) target in the range of 1.2–1.4 for new data centers and less than 1.5 for existing data centers	<p>The RSF data center had an average PUE of 1.15</p> <p>The high performance computing data center had an average PUE of 1.03</p>	Target Met
Organizational Resilience		
Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols.	<p>Added language to the telecommute policy to encourage staff to telecommute during adverse weather conditions</p> <p>Installed a long range acoustical device to notify employees of hazards on the STM site</p> <p>Investigated the installation of innovative sensors to monitor environmental conditions</p> <p>Developed a power systems model to determine “islanding” requirements for the RSF data center</p>	Target Met

2017 Accomplishments and Highlights

- As indicated in Table 2, NREL met all sustainability goals set by DOE except the petroleum reduction goal. Attainment of this goal will require replacing some/all of NREL's diesel shuttle buses with zero-emissions vehicles, for which funding and vehicle options may not be available.
- The laboratory achieved third-party certification to ISO 50001:2011 Energy Management.
- The laboratory continued development of the intelligent campus platform, which delivers reliable data metrics for building analytics to increase energy efficiency across the laboratory. This included the continued roll out of a fault detection diagnostics software program.
- Through the retirement of legacy equipment and upgrades to current IT equipment, NREL's already extremely energy efficient RSF data center achieved a PUE of 1.15. PUE is the ratio of total amount of energy used by a computer data center to the energy delivered to computing equipment. An ideal PUE is 1.0.
- In the Energy Systems Integration Facility, NREL installed a thermosyphon on the high performance computing data center, which significantly reduced water consumption while maintaining a world-class PUE rating of 1.03.



NREL employees can participate in ongoing research and charge their electric vehicles in the main parking garage. Researchers are developing methods to match electric vehicle charging requirements with solar PV generation. *Photo by Matthew Staver, NREL 39225*

2017 Compliance Summary and Activities

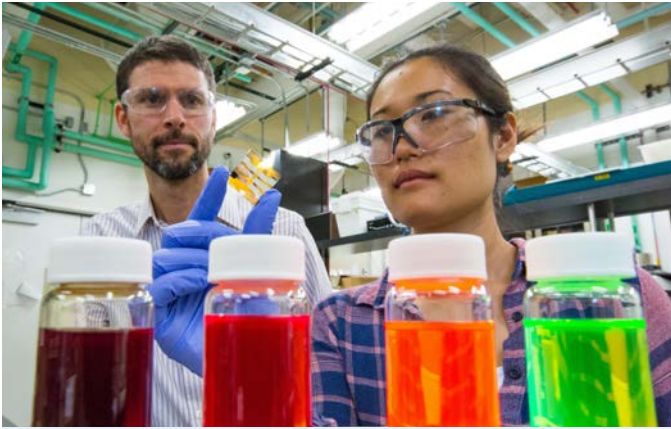
- Program activities were in compliance with requirements.

3.2 Climate Change Adaptation Management

As the effects of climate change become more apparent worldwide, NREL is proactively engaged in mitigation and adaptation strategies to manage site-specific climate risks and improve resiliency of operations to ensure continuity of achieving the laboratory's mission.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements
- The laboratory continued to encourage staff to telecommute during adverse weather conditions and updated the telecommute policy to reflect this change
- The laboratory continued to support DOE's Sustainability Performance Office in developing guidance tools for climate change resilience planning. Specifically, an instructional tutorial was created to explain how DOE sites and offices can conduct their own climate change resilience screenings.
- The laboratory continued to identify and implement strategies, which stem from the findings of NREL's Climate Change Resilience study (2014), to increase climate resilience. In FY2017 NREL:
 - Installed a long-range acoustical device on the STM site to notify employees and visitors of hazards, including inclement weather announcements
 - Continued NREL's Chief Operating Officer regular communications via email about seasonal weather events that could impact staff working schedules and ability to reach the sites
 - Investigated the installation of innovative sensors that would deliver data to monitor air quality, weather conditions, water quality, and transportation patterns and issues to enhance the laboratory's response plans to impactful conditions
 - Developed a power systems model to determine requirements to isolate the RSF data center during extended power outages.



4 COMPLIANCE SUMMARY

NREL researchers work to enhance the efficiency of quantum dot solar cells in converting sunlight to electricity. *Photo by Werner Slocum, NREL 46864*

NREL is subject to many federal and state laws and regulations, as well as Executive 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. More detailed information for each area of compliance is found in the referenced sections of this report. (For more 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 & Requirement
Report	<p>DOE Order 231.1B, <i>Chg 1, Environment, Safety and Health Reporting</i>, was implemented to ensure that 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.</p>	<p>NREL reports annually via this Environmental Performance Report.</p>	<p>DOE: DOE Order 231.1B, <i>Chg 1</i></p>
EMS and Sustainability	<p>Executive Order 13693, <i>Planning for Sustainability in the Next Decade</i>, establishes updated goals for environmental sustainability in the federal government. These goals require federal facilities to conserve natural resources, reduce energy use and greenhouse gas emissions, develop renewable energy, manage buildings and transportation in a sustainable manner, and support pollution prevention.</p> <p>EO 13693, together with DOE Order 436.1, <i>Departmental Sustainability</i>, 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.</p>	<p>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, and progress is tracked throughout the year.</p> <p>NREL's EMS is certified to the ISO 14001:2015 international standard for environmental management systems and has been certified to ISO 14001 since 2011. Annual assessments verify that NREL meets the ISO standard and is continually improving performance.</p>	<p>Executive Order: EO 13693</p> <p>DOE: DOE Order 436.1</p>
Climate Change Adaptation Management	<p>EO 13653, <i>Preparing the United States for the Impacts of Climate Change</i>, and DOE Order 436.1, <i>Departmental Sustainability</i>, requires NREL to include in its Site Sustainability Plan the progress the laboratory has made in meeting the climate change resilience goals specified in EO 13693. However, EO 13653 was rescinded on March 28, 2017.</p>	<p>Program activities were in compliance with requirements.</p> <p>The laboratory continued to encourage staff to telecommute during adverse weather conditions and updated the telecommute policy to reflect this change.</p> <p>The laboratory continued to support DOE's Sustainability Performance Office in developing guidance tools on climate change resilience planning. Specifically, created an instructional tutorial explaining how DOE sites and offices can conduct their own climate change resilience screenings.</p> <p>The laboratory continued to identify and implement strategies, which stem from the findings of NREL's Climate Change Resilience study (2014), to increase climate resilience.</p>	<p>Executive Orders: EO 13653 (rescinded) EO 13693</p> <p>DOE: DOE Order 436.1</p>

Report Sections	Regulatory Program Description	Compliance Status	Regulator & Requirement
Air Quality	<p>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 greenhouse gases.</p> <p>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, and operations, depending upon the type and amount of air pollutants emitted. Generally, these requirements become stricter as the quantity of air pollutants emitted increases, or the air pollutants have a higher potential for harm or adverse effect.</p> <p>Greenhouse gases 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 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 upon which to base future greenhouse gas regulations. Reporting and permitting of greenhouse gases may be required under the EPA Prevention of Significant Deterioration regulation, Title V Tailoring Rule, and is required under the EPA Greenhouse Gas Mandatory Reporting Rule.</p> <p>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 greenhouse gases in the permit if carbon dioxide equivalent emissions are greater than 100,000 U.S. tons (90,718 MT) per year.</p> <p>EPA's Protection of Stratospheric Ozone (40 Code of Federal Regulations [CFR 82]) requires that servicing records must be kept for appliances containing more than 50 pounds (23 kilograms) of Class 1 or 2 Ozone Depleting Substances refrigerant.</p> <p>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 longer 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.</p>	<p>Program activities were in compliance with requirements. NREL did not exceed any air permit standard or other air regulatory requirement at any facility.</p> <p>An evaluation of hazardous air pollutant (HAP) emissions indicated that emissions for each individual facility were well below the reporting and permitting thresholds of 10 tons (9.1 MT) per year for each individual HAP or 25 tons (22.7 MT) per year for all HAPs combined.</p> <p>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.</p> <p>The required annual street sanding report was provided to the state and Jefferson County confirming that no sand was used at the STM site or the NWTC.</p> <p>The laboratory evaluated carbon-dioxide equivalent (CO₂e) and greenhouse gas emissions and concluded that they were below the federal reporting and permitting threshold of 27,500 tons (25,000 MT).</p> <p>All equipment registrations, including annual registration renewals, for state-required ozone-depleting substances were completed for the STM site and the NWTC. Per federal requirements, refrigerant recovery equipment has also been registered with the EPA.</p> <p>Two Air Pollutant Emission Notices for research power generators were renewed.</p>	<p>National Ambient Air Quality Standards: 40 CFR 50</p> <p>Ozone Depleting Substances (ODS): 40 CFR 82 and CDPHE Colorado Code of Regulations (CCR) 1001-19, Reg. 15</p> <p>New Source Performance Standards: 40 CFR 60</p> <p>New Source Review, Prevention of Significant Deterioration: 40 CFR 51</p> <p>Title V: 40 CFR 70 and 71</p> <p>National Emission Standards for Hazardous Air Pollutants, Hazardous Air Pollutant: 40 CFR 63 and CDPHE 5 CCR 1001-5, Reg. 3</p> <p>Permitting: CDPHE 5 CCR 1001-5, Reg. 3</p> <p>Greenhouse Gas: 40 CFR 98 and 40 CFR 51, 52, 70, 71</p> <p>Street Sanding: CDPHE 5 CCR 1001-18, Reg. 16</p>

Report Sections	Regulatory Program Description	Compliance Status	Regulator & Requirement
<p>Drinking Water Quality</p>	<p>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.</p> <p>The Water Quality Control Division of CDPHE implements the federal Safe Drinking Water Act in Colorado under authority delegated by the EPA.</p>	<p>Program activities were in compliance with requirements.</p> <p>All monitored parameters met applicable requirements.</p> <p>Certified divers were contracted to perform inspections of the 2,000-gallon (7,580-liter) and 15,000-gallon (56,781-liter) fiberglass water storage tanks at the NWTC. Both tanks were found to be free of cracks and in overall good condition. These results were reported to the Water Quality Control Division of CDPHE in compliance with state drinking water requirements.</p> <p>Water samples were collected at five drinking water taps at the NWTC and analyzed for lead and copper concentration. All lead sample results were below both the maximum allowable concentration in drinking water and below the limit at which the chemical analysis method can detect lead. Copper levels ranged from 0.060 mg/L to 0.338 mg/L, far below the maximum allowable concentration in drinking water of 1.3mg/L. These results were reported to the Water Quality Control Division of CDPHE, as required.</p> <p>The drinking water supply at the NWTC was interrupted on November 6, 2017, when a pipe within the distribution system burst. Repairs were made and water service was restored the same day. Water quality standards remained in compliance prior to and after the disruption in service.</p> <p>A total of 439,448 gallons (1,663,491 liters) of drinking water were provided to NWTC users.</p>	<p>EPA: 40 CFR 141-149</p> <p>CDPHE: 5 CCR 1002-11 Reg. 11</p>
<p>Groundwater Quality</p>	<p>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, geothermal, irrigation, livestock watering, dewatering, monitoring, and geothermal well installations.</p>	<p>Program activities were in compliance with requirements.</p> <p>Three groundwater wells installed immediately north of the Field Testing Laboratory Building in 2015 continued to be monitored to determine if groundwater or surface water was responsible for seepage into the building that occurred under the north foundation wall.</p>	<p>CDPHE: 5 CCR 1002-41 2 CCR 402-2 2 CCR 402-10</p>

Report Sections	Regulatory Program Description	Compliance Status	Regulator & Requirement
<p>Surface Water Quality</p>	<p>Surface water quality is controlled through the federal Clean Water Act (CWA), Energy Independence and Security Act of 2007, EO 13693, <i>Planning for Federal Sustainability in the Next Decade</i>, and the Colorado Water Quality Control Act.</p> <p>Stormwater discharges resulting from construction activities at federal facilities that disturb greater than one acre are administered in Colorado by the EPA. To obtain coverage under the 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.</p> <p>The Water Quality Control Division within CDPHE regulates stormwater discharges at non-federal facilities within Colorado. For NREL construction projects that occur off federal property, a Colorado Discharge Permit System stormwater permit may be required.</p> <p>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.</p> <p>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.</p> <p>EO 13693, <i>Planning for Federal Sustainability in the Next Decade</i>, directs federal agencies to install appropriate green infrastructure features to improve stormwater management.</p>	<p>Program activities were in compliance with requirements.</p> <p>Permit coverage for an ongoing project at the STM site was transferred from the 2012 EPA Construction Permit to the EPA's new 2017 Construction General Permit, and later amended to reflect modified project scope and schedule.</p> <p>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 the EPA Construction General Permit, as well as smaller areas where permit coverage is not required but where stormwater best management practices are followed.</p> <p>EPA Region 8 representatives visited the STM site at NREL's request to provide clarification on stormwater Construction General Permit requirements. The EPA expressed approval of NREL's stormwater management and their confidence in NREL's protection of downstream surface water quality.</p>	<p>EPA: 40 CFR 122.26</p> <p>CDPHE: 5 CCR 1002-61 Regs. 38, 61, 65, and 93</p> <p>Executive Order: EO 13693</p>
<p>Wastewater</p>	<p>Wastewater is regulated at the federal level under the Clean Water Act and at the state level under the Colorado Water Quality Control Act by the Water Quality Control Division of CDPHE.</p> <p>The Metro Wastewater and Reclamation District (Metro District) manages wastewater at its treatment plant per federal and state requirements. Domestic and non-domestic wastewater flows are delivered to the Metro District's plant via conveyance systems owned, operated, and regulated by numerous sanitation districts.</p> <p>Non-domestic wastewater discharges to the Metro District must comply with the Metro District's rules and regulations which incorporate requirements of the Clean Water Act.</p> <p>Onsite 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.</p>	<p>Program activities were in compliance with requirements.</p> <p>The Metro Wastewater Reclamation District and Pleasant View Water and Sanitation District visited the STM site to tour current research operations that discharge to the sanitary sewer and to discuss reporting requirements.</p>	<p>EPA: 40 CFR 122-136</p> <p>CDPHE: 5 CCR 1002-62, 63</p>

Report Sections	Regulatory Program Description	Compliance Status	Regulator & Requirement
<p>Hazardous Materials Management</p>	<p>Hazardous material management is regulated at the federal level through the Superfund Amendments and Reauthorization Act Title III, which is also known as the 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.</p> <p>Section 302 of EPCRA requires a facility to notify the 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.</p> <p>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.</p> <p>In accordance with Sections 311 and 312 of EPCRA, NREL provides Safety Data Sheets for chemicals that are 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.</p> <p>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.</p> <p>Annual hazardous materials permits are required by West Metro Fire Rescue for the STM site and Denver West Office Park. Permits are issued for a total of seven buildings where hazardous materials are stored and/or used. Prior to issuing the permits, a representative from West Metro Fire Rescue conducts a walk-through inspection of the entire STM site and Denver West Office Park.</p> <p>The Renewable Fuels and Lubricants Research Laboratory, 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.</p> <p>Hazardous materials permits are currently not required at the NWTC or the Joyce Street Facility.</p>	<p>Program activities were in compliance with requirements.</p> <p>There were no releases of hazardous materials that required reporting. In accordance with DOE requirements, NREL screened selected chemicals to confirm that quantities fell below those requiring elevated operational protocols.</p> <p>EPCRA Tier II hazardous materials reports were submitted for two facilities for reporting year 2017. 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, and sulfuric acid contained in sealed lead-acid batteries.</p> <p>The Denver Fire Department issued a hazardous materials permit for the Renewable Fuels and Lubricants Research Laboratory.</p>	<p>EPA: 40 CFR 355, 370, 372</p> <p>Executive Order: EO 13693</p> <p>DOE: DOE Order 151.1D</p>

Report Sections	Regulatory Program Description	Compliance Status	Regulator & Requirement
<p>Hazardous Waste Management</p>	<p>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.</p> <p>NREL maintains unique EPA identification numbers for each of its five facilities: STM site, Denver West Office Park, NWTC, Joyce Street Facility, 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.</p> <p>The three waste generator classifications are:</p> <ul style="list-style-type: none"> • Large Quantity Generator • Small Quantity Generator • Conditionally Exempt Small Quantity Generator. <p>Four out of five of NREL's sites fall under the Conditionally Exempt Small Quantity Generator category because they generate minimal amounts of hazardous waste per calendar month. The STM site typically produces quantities of hazardous waste well within the Small Quantity Generator category; however, due to pilot-scale research experiments, the STM site can episodically elevate to the Large Quantity Generator category in one or more months during the year.</p>	<p>Program activities were in compliance with requirements.</p> <p>Nineteen hazardous and 12 universal waste shipments for offsite disposal and recycling were made across NREL's five sites.</p> <p>Mandatory employee training on hazardous and universal waste management was completed in compliance with state and federal regulations.</p> <p>All regulatory notifications were submitted and applicable waste generator fees were paid.</p>	<p>EPA: 40 CFR 260- 280</p> <p>CDPHE: 6 CCR 1007-3</p>
<p>Aboveground Storage Tank Management</p>	<p>Aboveground storage tanks (AST) are regulated in Colorado by the Colorado Department of Labor and Employment's (CDLE) Division of Oil and Public Safety (DOPS) under the Colorado Aboveground Storage Tank regulation.</p> <p>ASTs with capacities of 660 gallons (2,498 liters) or larger must be permitted prior to installation, inspected by the state following installation, registered with the state within 30 days following commencement of use, and registration renewals submitted annually thereafter.</p> <p>Regulations require that ASTs be constructed and installed according to specific standards, be regularly inspected with all inspections documented, and that facilities meeting certain oil storage quantities employ a Spill Prevention, Control, and Countermeasures plan to manage oil sources 55 gallons (208 liters) or larger.</p>	<p>Program activities were in compliance with requirements.</p> <p>All tanks were inspected to confirm continued adherence to state of Colorado regulations.</p> <p>Annual AST training was provided to 26 staff members identified as having responsibility for operating and fueling ASTs or performing oversight for tank safety and environmental compliance.</p> <p>Eight ASTs were painted as part of a tank maintenance effort.</p>	<p>CDLE: DOPS Storage Tank Regulations 7 CCR 1101-14</p> <p>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.)</p>

Report Sections	Regulatory Program Description	Compliance Status	Regulator & Requirement
<p>Spill Prevention and Response</p>	<p>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.</p> <p>Spill Prevention, Control, and Countermeasures (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 liters) of oil and have the potential for a spill to enter waters of the United States or state of Colorado waters must have a SPCC plan. SPCC regulations require that any equipment or containers with the capacity to store 55 gallons (208 liters) or more of oil be included in the plan.</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>No reportable spills occurred. Nine minor spills of diesel, lubricant, coolant, and hydraulic fluids occurred at the STM site, and no spills occurred at the NWTC. The size of spills ranged from less than 0.1 gallon to 4 gallons (0.38 to 16 liters), with a total quantity of 7.6 gallons (28 liters). Eighty percent of these spills were from vehicles and mobile equipment and occurred on paved surfaces. Each spill received immediate remedial action and there was no significant impact to the environment.</p> <p>The SPCC training required annually of all workers who manage fuel storage tanks was revised to include an updated spill history.</p>	<p>EPA: Oil Pollution Prevention 40 CFR 112</p> <p>CWA Section 319</p> <p>CDLE: DOPS Storage Tank Regulations, 7 CCR 1101-14</p> <p>CWCC: 25-8-205 CRS.</p>
<p>Radiological Materials and Waste Management</p>	<p>Air emissions are regulated by Section 112 of the Clean Air Act and implemented by the EPA. 40 CFR Part 61 established National Emission Standards for Hazardous Air Pollutants and, more specifically, Subpart H sets such standards for radiological materials.</p> <p>DOE Order 458.1, <i>Radiation Protection of the Public and the Environment</i>, 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 mrem per year or greater.</p>	<p>Program activities were in compliance with requirements.</p> <p>Only small quantities (less than 1 cubic yard [0.76 cubic meter]) of low-level radioactive waste are currently in storage awaiting off-site disposal.</p> <p>A ventilation exhaust hood was removed during decommissioning of the laboratory's only low-level radioactive work area. Radiological sampling indicated the hood was within limits for release and would not pose a hazard to workers, the public, or the environment.</p> <p>However, the hood was placed in the metal recycle bin without following established internal procedures. An event investigation was completed and the following corrective actions identified: (1) modify the work control process to eliminate multiple-copy work orders and prominently identify special instructions, and (2) mark as-built facility drawings to communicate prior radiological use and identify the need for special instructions for future facility modifications.</p> <p>In accordance with a federal regulation and DOE Order, NREL submitted its annual <i>Radionuclide Air Emissions Annual Report</i> to the EPA confirming that the laboratory is in compliance with air emissions standards. For calendar year 2017, the effective dose equivalent of radiation to the public was 0.045 millirem (mrem) per year, far below the 10 mrem per year limit.</p>	<p>EPA: 40 CFR 61, Subpart H</p> <p>DOE: DOE Order 458.1</p>

Report Sections	Regulatory Program Description	Compliance Status	Regulator & Requirement
<p>National Environmental Policy Act</p>	<p>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.</p> <p>DOE regulations and orders establish how NEPA is implemented for DOE, and the Council on Environmental Quality reviews and approves federal agency NEPA procedures.</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>A total of 159 documented environmental evaluations were completed; 132 actions were covered by a Programmatic NEPA Determination; and 27 actions were submitted to DOE for review.</p> <p>Quarterly monitoring of the NEPA program was conducted to confirm that the appropriate level of NEPA evaluation (either application of a Programmatic NEPA Determination or review by DOE) was completed for maintenance, contracting, and purchasing activities. Results indicate that established procedures are effective, and proposed activities received the appropriate level of review.</p>	<p>Council on Environmental Quality: 40 CFR 1500-1508</p> <p>DOE: 10 CFR 1021</p>
<p>Wildlife Management</p>	<p>The Migratory Bird Treaty Act (MBTA) of 1918, as implemented by the U.S. Fish and Wildlife Service, 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.</p> <p>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 U.S. Fish and Wildlife 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 non-lethal measures taken to prevent depredation of agricultural crops and to protect public health and safety.</p> <p>Within the state of 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.</p> <p>Under the Memorandum of Understanding between DOE and the U.S. Fish and Wildlife Service Regarding Implementation of EO 13186, <i>Responsibilities of Federal Agencies to Protect Migratory Birds</i>, 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.</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>Ground-nesting-bird surveys were conducted prior to annual mowing and weed control operations at the NWTC in conformance with the Migratory Bird Treaty Act. A Vesper Sparrow (<i>Pooecetes gramineus</i>) nest was found and cordoned off; mowing was delayed in that area until it was clear that the eggs had hatched and the young had permanently left the nest.</p>	<p>U.S. Fish and Wildlife Service: MBTA 16 U.S.C. 703-712</p> <p>Colorado Division of Parks and Wildlife: CRS 33-6-128</p> <p>Memorandum of Understanding between DOE and the U.S. Fish and Wildlife Service</p> <p>Executive Order: EO 13186</p> <p>Presidential Memorandum – Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators</p>

Report Sections	Regulatory Program Description	Compliance Status	Regulator & Requirement
<p>Endangered Species and Species of Concern</p>	<p>The Endangered Species Act (ESA), jointly administered by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, protects threatened and endangered wildlife and plant species and associated critical habitat.</p> <p>Federal agencies are required to abide by the Endangered Species Act to ensure that their actions do not adversely affect species that are federally listed under the Act as threatened, endangered, or candidate species.</p> <p>Additional federal and state laws and regulations protect wildlife, such as the Bald and Golden Eagle Protection Act.</p> <p>DOE's formal consultation with the U.S. Fish and Wildlife Service for the 2014 site-wide environmental assessments for the STM site and NWTC resulted in an agreed-upon threshold for water usage to limit impacts to the Platte River system.</p> <p>The Colorado Division of Parks and Wildlife identifies 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 Endangered Species Act that considers rare plants.</p>	<p>Program activities were in compliance with requirements.</p> <p>No activities were conducted in designated critical habitat for the federally threatened Preble's meadow jumping mouse (<i>Zapus hudsonius preblei</i>).</p> <p>The 23.9 million gallons (90.6 million liters) of water used at the STM site and the NWTC were reported to the U.S. Fish and Wildlife Service and fell below the agreed-upon limit of 39.5 million gallons (149.7 million liters) per year.</p>	<p>U.S. Fish and Wildlife Service: 50 CFR 17</p> <p>Colorado Division of Parks and Wildlife: 2 CCR 406-10, Article 2 and 3</p>

Report Sections	Regulatory Program Description	Compliance Status	Regulator & Requirement
<p>Vegetation Management</p>	<p>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.</p> <p>In Colorado, the Department of Agriculture Commissioner 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.</p> <p>EO 13112, <i>Invasive Species</i>, requires the control of invasive species at federal facilities.</p>	<p>Program activities were in compliance with requirements.</p> <p>At the NWTC, herbicides were applied to approximately 345 acres (140 hectares) to control B- and C-listed weeds in May and June, as well as 10 acres (4 hectares) in September.</p> <p>At the STM site, herbicides were applied to control A-, B-, and C-listed weeds to approximately 40 acres (16 hectares) in April and May, including applications on the mesa top conservation easement; 12 acres (5 hectares) in June; and 5 acres (2 hectares) in August.</p> <p>NREL biologists introduced bindweed mites to combat bindweed on the STM site. Biological control specimens were provided by the Colorado Department of Agriculture State Insectary in Palisade, Colorado.</p> <p>The north and west sides of the RSF building were sprayed with a half-strength solution of Roundup®. This mixture selectively targets cheatgrass, a List-C noxious weed, that is first to emerge from dormancy in the late winter. Over the past three years this technique has increased the productivity of native grasses around the building.</p> <p>Herbicides were applied in April and May to a large tract (32 acres [13 hectares]) of grassland within the STM site conservation easement. The application targeted cheatgrass, dalmatian toadflax, and thistle.</p> <p>Russian olive trees were identified and mapped on the STM site during a natural resource inspection. The trees were treated with Roundup after girdling live branches, but a few tenacious trees are under consideration for "chainsaw treatment."</p> <p>Through consistent monitoring and working with the Colorado Department of Agriculture, two additional noxious weed species were identified at the NWTC: sulfur cinquefoil and moth mullein (<i>Verbascum blattaria</i>). The invasive sulfur cinquefoil was treated in 2017 and treatments will continue in 2018. The slow-growing moth mullein will be incorporated in continuous plans to combat common mullein (<i>Verbascum thapsus</i>) as management practices for both species are similar.</p> <p>One new APHIS permit for the import of <i>Linum usitatissimum</i> (otherwise known as flax or linseed) stems from Canada was obtained. Two permits expired for napier grass (<i>Pennisetum purpureum</i>), sugarcane (<i>Saccharum officinarum</i>) bagasse, and sugarcane leaves and plant tops.</p>	<p>Executive Order: EO 13112</p> <p>EPA: 40 CFR 162-171(f)</p> <p>CRS 35-5.5</p> <p>Department of Agriculture: Federal Noxious Weed Act of 1974 (Public Law 93-629, 88 Statute 2148)</p> <p>Plant Protection Act (Public Law 106-224)</p> <p>Federal Insecticide, Fungicide, and Rodenticide Act 7 USC 136 et seq.</p>

Report Sections	Regulatory Program Description	Compliance Status	Regulator & Requirement
<p>Wetlands and Floodplains</p>	<p>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.</p> <p>Under EO 11990, <i>Wetlands Protection</i>, 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.</p> <p>EO 11988, <i>Floodplain Management</i>, 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.</p> <p>Counties protect floodplains by mapping the 100-year floodplain boundaries within their jurisdiction in coordination with the Federal Emergency Management Agency. They then formulate regulations to control the type and amount of development within the designated boundary.</p> <p>Jefferson County requires approval of development proposed in floodplains within its jurisdiction.</p>	<p>Program activities were in compliance with requirements.</p> <p>New wetlands were observed in stormwater detention basins and drainageways on the STM site during vegetation surveys. These new wetlands contribute to the overall acreage in Table 8.</p>	<p>USACE: CWA Section 404</p> <p>Executive Orders: EO 11988 EO 11990</p> <p>DOE: 10 CFR 1022</p>
<p>Cultural Resources</p>	<p>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 & Historic Preservation (State Historic Preservation Officer).</p> <p>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.</p>	<p>Program activities were in compliance with requirements.</p> <p>ESH&Q staff took baseline measurements of a crack in the STM ammunition igloo. The crack will be measured periodically to determine if the crack is expanding.</p> <p>A cultural resource review was conducted for a portion of the NWTC along the northwestern corner of the site where future utility line projects will occur. No cultural resources were found.</p>	<p>Advisory Council on Historic Preservation: 36 CFR 60 36 CFR 63 36 CFR 79 36 CFR 800 16 U.S.C. 470</p> <p>SHPO: 8 CCR 1504-7</p>



5 AIR QUALITY PROTECTION

Typical Renewable Fuel Heat Plant exhaust plume. The visible plume is moisture condensation and has a very low opacity level due to clean combustion and an efficient particulate removal system. *Photo by Larry Durbin, NREL 50126*

Good air quality is fundamental to the overall well-being of individuals and the environment. Each person inhales approximately 3,700 gallons (14,000 liters) of air per day, and contaminants that may be present can affect the individuals' health. Air pollutants in the environment also can affect the 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 (carbon monoxide, nitrogen oxides, volatile organic compounds, particulate matter, and sulfur dioxide) and non-criteria pollutants (hazardous air pollutants, greenhouse gas 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 assure permit and regulatory compliance and address air quality considerations.

The primary sources of regulated pollutants at NREL are a result of fuel use, laboratory 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 operations maintenance activities.

A summary of NREL facility estimated annual air pollutant emissions is included in Table 4.

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

2017 Accomplishments and Highlights

- Fleet vehicle emissions were quantified as part of the ongoing effort to track laboratory air emissions and operational environmental impact. In the most recent period for which emissions have been quantified—calendar year 2016—NREL operated 45 motor vehicles using a total of 43,266 gallons (163,799 liters) of E85 and diesel fuels and traveled a total of 260,870 miles (419,830 km). This vehicle use resulted in the emission of 1.26 tons (1.14 MT) of CO, 0.18 tons (0.16 MT) of NO_x and 0.04 tons (0.036 MT) of volatile organic compound.
- Cooling tower particulate emissions were quantified and added to the 2017 air emission inventory. These particulate emissions result from the evaporation of cooling water mist allowing dissolved solids in the water to enter the air. Fine particulate, which can cause health impacts, is measured as PM₁₀ and consists of particulates smaller than 10 microns in diameter. Total cooling tower emissions were calculated to be approximately 0.05 tons (0.045 MT) per year of PM₁₀.
- An inventory of laboratory refrigerants used for both research and operational activities was updated for use in long-term compliance tracking.
- A Class II ozone-depleting substance in the amount of 140 pounds (64 kilograms) was recovered and recycled during a chiller upgrade project. The replacement system uses a non-ozone-depleting substance refrigerant.
- An internal assessment was completed; no non-conformities or opportunities for improvement were identified.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- An evaluation of hazardous air pollutant (HAP) emissions indicated that emissions for each individual facility were well below the reporting and permitting thresholds of 10 tons (9.1 MT) per year for each individual HAP or 25 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.
- The required annual street sanding report was provided to the state and Jefferson County confirming that no sand was used at the STM site or the NWTC.
- The laboratory evaluated carbon-dioxide equivalent (CO₂e) and greenhouse gas emissions and concluded that they were below the federal reporting and permitting threshold of 27,500 tons (25,000 MT).
- All equipment registrations, including annual registration renewals, for state-required ozone-depleting substances were completed for the STM site and the NWTC. Per federal requirements, refrigerant recovery equipment has also been registered with the EPA.
- Two Air Pollutant Emission Notices for research power generators were renewed.

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

Year	CRITERIA POLLUTANTS					GREENHOUSE GASES			HAPs
	CO	NO _x	VOC	PM ₁₀	SO ₂	CO ₂	CH ₄	N ₂ O	Total
2013	6.02 (5.46)	13.83 (12.55)	0.47 (0.42)	3.16 (2.87)	0.36 (0.32)	8,584 (7,787)	0.51 (0.46)	0.25 (0.23)	0.51 (0.46)
2014	6.25 (5.67)	14.68 (13.32)	0.48 (0.43)	3.90 (3.53)	0.45 (0.41)	9,299 (8,436)	0.55 (0.50)	0.30 (0.27)	0.62 (0.56)
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)

*Abbreviations: HAPs – hazardous air pollutants, CO – carbon monoxide, NO_x – nitrogen oxides, VOC – volatile organic compounds, PM₁₀ – respirable particulate matter less than 10 microns in diameter, SO₂ – sulfur dioxide, CO₂ – carbon dioxide, CH₄ – methane, N₂O – nitrous oxide



6 WATER QUALITY PROTECTION

Stormwater outfall that directs runoff to the STM site detention basin. Grouted riprap prevents erosion of soil on steep slopes while wetland vegetation slows the flow of stormwater and encourages nutrient and urban pollutant uptake. *Photo by Dennis Schroeder, NREL 45400*

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 regarding program management for each of these four areas can be found in Appendix A.

6.1 Drinking Water

The STM site and the NWTC are provided with potable drinking water by two different means. The 2,200 staff members at the STM site are 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. Because the NWTC is not located within the bounds of a municipal public water supply distribution system, treated water, which originates in large part from the Boulder Creek watershed and, to a lesser degree, some watersheds on the western slope of Colorado, is purchased from the City of Boulder and transported by truck to the site for the 150 employees located there. Upon delivery to the NWTC, the trucked water is transferred to a large holding tank with a capacity of 15,000 gallons (56,781 liters). 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 prior to distribution to site buildings.

The state of Colorado permits the NWTC drinking water system. Weekly monitoring and periodic required sampling is conducted by a subcontractor to NREL, 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 and Figure 4 show the results of chlorine and disinfection byproducts monitoring at the NWTC during 2017.

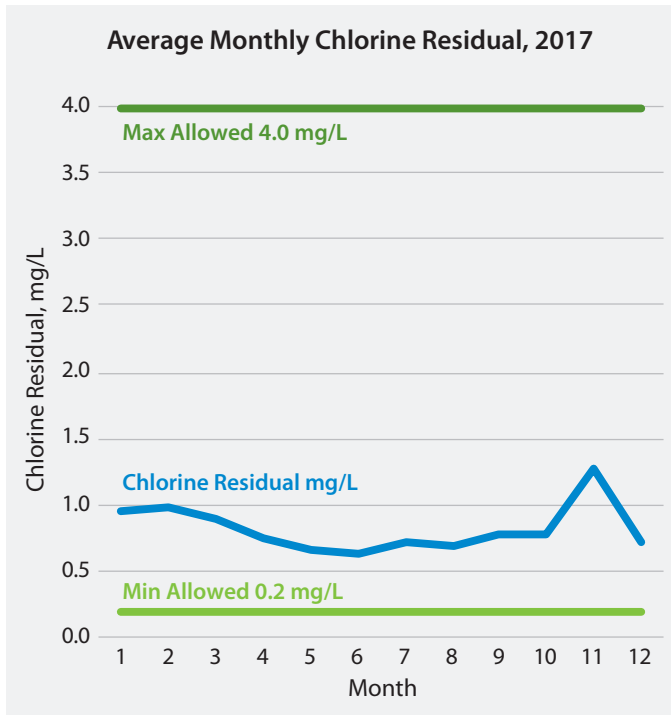


Figure 3. Results of 2017 average monthly chlorine residual monitoring at the NWTC

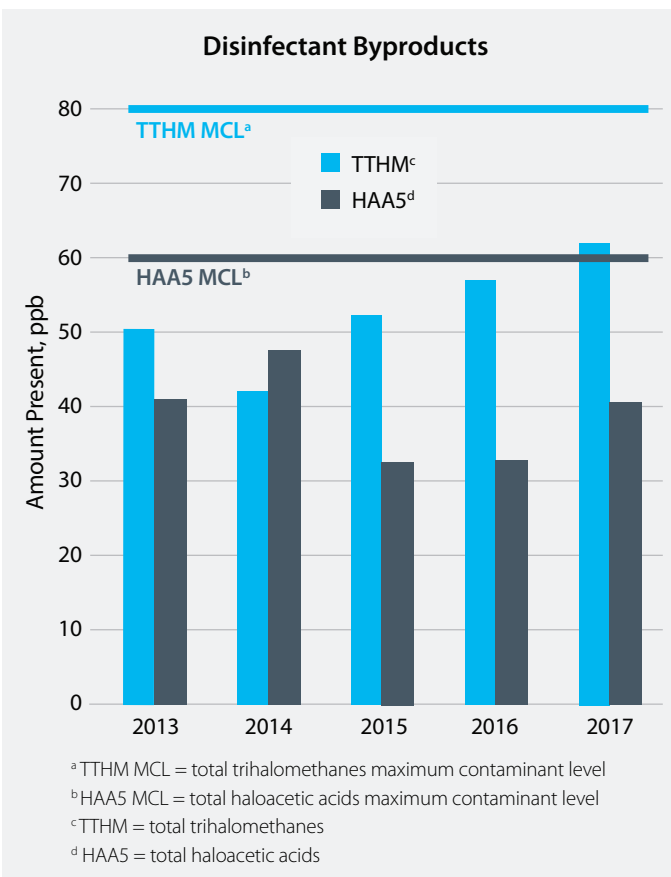


Figure 4. Comparison of disinfection byproducts monitoring at the NWTC, 2013–2017

2017 Accomplishments and Highlights

- The monthly disinfectant byproduct sampling program that began in December 2016 was completed in December 2017. Disinfectant byproduct results were collected by the City of Boulder, the NWTC’s water provider, within their distribution system. The data that correlate with NREL collection periods will be obtained and analyzed in 2018 to help identify additional operational practices that will minimize disinfectant byproduct formation and provide water that meets all regulatory requirements.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- All monitored parameters met applicable requirements.
- Certified divers were contracted to perform inspections of the 2,000-gallon (7,580-liter) and 15,000-gallon (56,781-liter) fiberglass water storage tanks at the NWTC. Both tanks were found to be free of cracks and in overall good condition. These results were reported to the Water Quality Control Division of the CDPHE in compliance with state drinking water requirements.
- Water samples were collected at five drinking water taps at the NWTC and analyzed for lead and copper concentration. All lead sample results were below both the maximum allowable concentration in drinking water and below the limit at which the chemical analysis method can detect lead. Copper levels ranged from 0.060 mg/L to 0.338 mg/L, far below the maximum allowable concentration in drinking water of 1.3mg/L. These results were reported to the Water Quality Control division of CDPHE, as required.
- The drinking water supply at the NWTC was interrupted on November 6, 2017, when a pipe within the distribution system burst. Repairs were made and water service was restored the same day. Water quality standards remained in compliance prior to and after the disruption in service.
- A total of 439,448 gallons (1,663,491 liters) of drinking water were provided to NWTC users.

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 east to near Limon. The aquifer provides groundwater supplies to urban, rural, and agricultural users. The aquifers within the Denver Basin 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 site and the NWTC are located at the western edge of the Denver Basin aquifer system.

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

Despite the low likelihood of reaching the Dawson aquifer, NREL's groundwater management program is focused on the control of potential pollutant sources that could affect this important resource. This 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 site and no monitoring wells at the NWTC. There are two permitted closed-loop geothermal systems in operation at the STM site; one is located at the Solar Radiation Research Laboratory and the second is located near the South Site Entrance Building. Both geothermal well systems were installed as part of research activities.

2017 Accomplishments and Highlights

- There were no spills or releases that impacted groundwater.



A subcontractor measures water levels and takes groundwater samples north of the Field Testing Laboratory Building.

Photo by Dennis Schroeder, NREL 49675

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- Three groundwater wells installed immediately north of the Field Testing Laboratory Building in 2015 continued to be monitored to determine if groundwater or surface water was responsible for seepage into the building that occurred under the north foundation wall.

6.3 Surface Water

Through its surface water program, NREL seeks to protect the quality of nearby receiving waters into which the STM site and the NWTC drain. These receiving waters include Lena Gulch at the STM site and Coal Creek and Rock Creek at the NWTC. 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



Erosion control blanket and underlying native seed surrounding electric car charging stations; the stations were installed as part of a research project to test equipment function and durability.

Photo by Genevieve Braus, NREL 49958

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.

2017 Accomplishments and Highlights

- Initial work began on a project at the STM site to stabilize the hillside adjacent to the Field Testing Laboratory Building. The building was damaged initially by a water line break and then further impaired by the erosive impacts of the September 2013 flood event. Completion of the project, which will install both retaining walls and stabilizing vegetation, is expected to be completed in 2018.
- Erosion and sediment control plans implemented on several small construction projects contributed to the preservation of topsoil and prevention of sediment deposition to nearby surface drainages.
- NREL staff attended a stormwater compliance training class at the Rocky Mountain Education Center. For some staff members, the training served to refresh their current knowledge and update them on new regulations and best management practices. For other staff members, the training provided a basis upon which to understand stormwater requirements, especially in their oversight role of construction subcontractors.
- NREL staff attended a stormwater workshop for federal facilities sponsored by EPA Region VIII. The workshop included in-depth discussions of implementation methods for current requirements and notice of upcoming regulatory changes.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- Permit coverage for an ongoing project at the STM site was transferred from the 2012 EPA Construction Permit to the EPA's new 2017 Construction General Permit, and later amended to reflect modified project scope and schedule.
- 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 the EPA Construction General Permit, as well as smaller areas where permit coverage was not required but where stormwater best management practices are followed.
- EPA Region 8 representatives visited the STM site at NREL's request to provide clarification on stormwater Construction General Permit requirements. The EPA expressed approval of NREL's stormwater management and their confidence in NREL's protection of downstream surface water quality.

6.4 Wastewater

Untreated or poorly treated wastewater has the potential to contaminate surface and groundwater used for drinking water, irrigation, industrial, commercial, and recreational purposes. The majority of wastewater from the STM site 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 Joyce Street Facility and the Renewable Fuels and Lubricants Research Laboratory also flows to the Metro District's treatment plant.

NREL's primary non-domestic wastewater discharge is generated at the STM site's Integrated Biorefinery Research Facility 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 a variety of fuels and chemicals. The pH of the effluent from this process is adjusted to fall within the targeted pH range of 5 to 11 prior to discharge into the sanitary sewer system. The Metro District and Pleasant View system managers periodically tour the facility and review operational controls.

For those facilities that lack sanitary service, there are three small septic systems in place, each consisting of a tank and a leach field. One is located at the STM mesa top Solar Radiation Research Laboratory and two are at the NWTC. A preventative maintenance and inspection program is in place to confirm proper system function.

2017 Accomplishments and Highlights

- The pH probe in the acid waste neutralization tank at the Integrated Biorefinery Research Facility was replaced with a new, more accessible meter to facilitate frequent and direct validation of the probe's accuracy; this helps to ensure that the discharge from the tank meets regulatory requirements.
- Commissioning was performed on equipment to support a new thin-film solar cell research tool. This included flow and pH monitoring to establish operating procedures for assuring the discharge falls within regulatory limits.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- The Metro District and Pleasant View staff visited the STM site to tour current research operations that discharge to the sanitary sewer and to discuss reporting requirements.



7 HAZARDOUS MATERIALS AND HAZARDOUS WASTE MANAGEMENT

Excess chemicals that were collected and disposed of per state and federal regulations. *Photo by Eric Schmitz, NREL 49539*

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 include:

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

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

7.1 Hazardous Materials Management

A variety of 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.

2017 Accomplishments and Highlights

- A coordinated excess chemical and research sample disposal effort was performed throughout two bioenergy research facilities.
- Fifty-two chemical storage cabinets were obtained to replace aging and deficient storage cabinets.

2017 Compliance Summary

- Program activities were in compliance with requirements.
- There were no releases of hazardous materials that required reporting. In accordance with DOE requirements, NREL screened selected chemicals to confirm that quantities fell below those requiring elevated operational protocols.
- Emergency Planning and Community Right-to-Know Act (EPCRA) Tier II hazardous materials reports were submitted for two facilities for reporting year 2017. 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, and sulfuric acid contained in sealed lead-acid batteries.
- The Denver Fire Department issued a hazardous-materials permit for the Renewable Fuels and Lubricants Research Laboratory.

Table 5. 2017 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 that NREL was not required to report because it did not meet the threshold or did not have an extremely hazardous substance release.

The specific reporting requirements for each EPCRA section outlined in Table 5 is defined in Section 4, Compliance Summary.

7.2 Hazardous Waste Management

Research and development activities and general 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)
- Non-hazardous 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, and electronic waste including computers, monitors, and research instrumentation containing electronic circuitry.

Table 6 provides a summary of the waste generated at NREL for the past 5 years.

Table 6. Comparison of Four Waste Categories Generated at NREL Facilities, in lbs. (kgs) Net Weight

	Hazardous Waste	Non-Hazardous Waste	Universal Waste Electronics	Other Universal Waste
2013	14,974 (6,792)	4,477 (2,031)	38,096 (17,280)	19,063 (8,647)
2014	14,683 (6,659)	15,198 (6,893)	28,551 (12,949)	6,738 (3,056)
2015	17,040 (7,729)	47,407 (21,503)	31,964 (14,499)	15,600 (7,076)
2016	14,234 (6,456)	17,340 (7,865)	14,028 (6,376)	8,686 (3,948)
2017	20,733 (9,404)	29,599 (13,425)	25,924 (11,759)	8,430 (3,824)

2017 Accomplishments and Highlights

- As a best management practice, NREL facilities are managed to the more stringent Large Quantity Generator hazardous waste regulations category, which specifies requirements for personnel training, contingency planning, and container labeling and management.
- Waste management storage and collection areas were established in the NWTC’s Composite Materials Education and Technology Facility in advance of start-up of operations.
- Numerous individual laboratory spaces were renovated, requiring advanced characterization and planning for the disposal of chemical gloveboxes, fume hoods, and exhaust ducting. While most equipment was manually decontaminated and recycled, two chemical gloveboxes were managed as hazardous waste.
- Authorizations and approvals were obtained to transport and dispose of one mobile data trailer containing non-friable asbestos in its interior from the NWTC in accordance with EPA, State of Colorado, and OSHA regulations.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- Nineteen hazardous and 12 universal waste shipments for offsite disposal and recycling were made from NREL's five sites.
- Mandatory training on employee 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.



A double-wall 200-gallon (757-liter) standby generator diesel fuel tank located at the NWTC. *Photo by Theodore DeVito NREL 50079*

7.3 Aboveground Storage Tank Management

Appropriate tank management prevents or minimizes spills and leaks of fuels or oils which 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. Five are located at the NWTC with a total capacity of 1,289 gallons (4,879 liters), one is located at the NREL-occupied laboratory at the Denver West Office Park with a capacity of 500 gallons (1,893 liters), and 20 are located at the STM site with a total capacity of 13,164 gallons (49,831 liters). All ASTs are maintained using best management practices and according to applicable regulations. Five ASTs at the STM site are registered with the state. There are no ASTs that require registration at the NWTC, Denver West Office Park, Renewable Fuels and Lubricants Laboratory, or Joyce Street Facility.

2017 Accomplishments and Highlights

- Two new, small research-generator ASTs provided by the U.S. Navy, which contain a combined 90 gallons (340 liters), were placed at the Energy Systems Integration Facility. These ASTs are below the state's 660-gallon installation permitting and registration threshold.

2017 Compliance Summary and Activities

- 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 26 staff members identified as having responsibility for operating and fueling ASTs or performing oversight for tank safety and environmental compliance.
- Eight ASTs were painted as part of a tank maintenance effort.

7.4 Spill Prevention and Response

Spills of chemicals, fuels, and oils 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 Countermeasures plans (SPCCs), can reduce spills and limit impacts to the environment when spills do occur.

SPCC plans have been developed and are in place for the NWTC, the STM site, and the Renewable Fuels and Lubricants Research Laboratory. As the total amount of oil stored at NREL's Joyce Street and Denver West Office Park facilities is less than 1,320 gallons (4,997 liters), SPCC plans are not required at those locations.

2017 Accomplishments and Highlights

- In addition to its routine training program, 35 NREL Chemical Emergency Response Team members participated in a 24-Hour Emergency Response Technician Level III training course to further enhance contingency planning and emergency preparedness.
- All spill kits were inventoried, inspected, and restocked.
- Spill-control planning continued to be refined and enhanced. Additional STM site maps were developed to identify recommended spill control points, and included the consideration of drainage width, ease of access, and ability to place sorbents or temporary containment structures.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- No reportable spills occurred. Nine minor spills of diesel, lubricant, coolant, and hydraulic fluids occurred at the STM site, and no spills occurred at the NWTC. The size of spills ranged from less than 0.1 gallon to 4 gallons (0.38 to 16 liters), with a total quantity of 7.6 gallons (28 liters). Eighty percent of these spills were from vehicles and mobile equipment and occurred on paved surfaces. Each spill received immediate remedial action and there was no significant impact to the environment.
- The SPCC training required annually of all workers who manage fuel storage tanks was revised to include an updated spill history.

7.5 Radiological Materials and Waste Management

The laboratory currently uses radiological materials in electron microscopy staining. A number of 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 and research.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- Only small quantities (less than 1 cubic yard [0.76 cubic meter]) of low-level radioactive waste are currently in storage awaiting off-site disposal.
- A ventilation exhaust hood was removed during decommissioning of the laboratory's only low-level radioactive work area. Radiological sampling indicated

the hood was within limits for release and would not pose a hazard to workers, the public, or the environment. However, the hood was placed in the metal recycle bin without following established internal procedures. An event investigation was completed and the following corrective actions identified: (1) modify the work control process to eliminate multiple-copy work orders and prominently identify special instructions, and (2) mark as-built facility drawings to communicate prior radiological use and identify the need for special instructions for future facility modifications.

- 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 2017, the effective dose equivalent of radiation to the public was 0.045 millirem (mrem) per year, far below the 10 mrem per year limit.

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, 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.



8 NATIONAL ENVIRONMENTAL POLICY ACT

NREL biologists completed a study that evaluated how seeding with different types of native grasses—along with different seed bed preparations, seed protective covers, and shade effects—would perform under an 8-acre, 1-MW photovoltaic array at the NWTC. This photo documents vegetation growth in one seed bed after 3 years. This study showed that short-growing, warm-season grasses, with or without cool-season, shade-tolerant species or legumes, could produce an extensive plant cover within a 3-year period. *Photo by David Buckner, NREL 49957*

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 are committed, such as federal funds, properties, facilities, employees, and equipment. NEPA mandates that the federal agencies weigh the potential for environmental impacts equally among all factors when making decisions about a proposed action.

In compliance with NEPA, potential environmental impacts from a wide range of activities conducted by NREL staff at both onsite and off-site facilities are evaluated prior to 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 regarding NREL's management of the NEPA program can be found in Appendix A.

2017 Accomplishments and Highlights

- Two NEPA overview sessions were provided to project managers and scientists to communicate NEPA's purpose, requirements, and key considerations for effective project planning.
- NREL and DOE Golden Field Office NEPA specialists identified continual improvement opportunities to enhance the quality and consistency of NEPA evaluations.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- A total of 159 documented environmental evaluations were completed; 132 actions were covered by a Programmatic NEPA Determination; and 27 actions were submitted to DOE for review.
- Quarterly monitoring of the NEPA program was conducted to confirm that the appropriate level of NEPA evaluation (either application of a Programmatic NEPA Determination or review by DOE) was completed for maintenance, contracting, and purchasing activities. Results indicate that established procedures are effective, and proposed activities received the appropriate level of review.



9 NATURAL AND CULTURAL RESOURCES PROTECTION

A Common Nighthawk (*Chordeiles minor*) uses camouflage to blend in at the NWTC. Photo by Jeroen Van Dam, NREL 49613.

Natural resources at the STM site and the NWTC 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 regarding program management for these five areas can be found in Appendix A.

9.1 Wildlife Management

Due to their location just east of the foothills of the Rocky Mountains, wildlife is plentiful at both the STM site and the NWTC. NREL promotes responsible management of wildlife and habitat through periodic formal surveys and review of impacts to wildlife when designing and implementing projects.

At the STM site, 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 in 2005 and in 2011. In 2017, the STM site was surveyed once again.

Mammals identified during the surveys at the STM site included mule deer, elk, coyotes, bobcat, striped skunks, rabbits, and various smaller mammals. More than 80 species of birds have been recorded by the formal wildlife surveys and supplemental employee observations. Over seven raptor species have been recorded at or above the STM site, especially during spring migration. Two raptor species are residents at the site: American Kestrel (*Falco sparverius*) and Red-tailed Hawk (*Buteo jamaicensis*). Owls also occupy the STM site, including the Great Horned Owl (*Bubo virginianus*). Recently, a Northern

Pygmy-Owl (*Glaucidium gnoma*) was heard during owl surveys.⁴ Reptiles and amphibians also inhabit the STM site. Most notably, the Woodhouse's toad (*Anaxyrus woodhousii*) breeds in ephemeral ponds on the STM conservation easement.

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 NWTC, 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 site. Raptor surveys were conducted at the NWTC in



A Vesper Sparrow (*Pooecetes gramineus*) nest found during nesting bird surveys at the NWTC. Photo by Kurt Schlomberg, NREL 45450

2017 Accomplishments and Highlights

- Acoustic bat monitoring at the NWTC was conducted by installing an acoustic recorder in the nacelle of a utility-scale turbine on the northeast portion of the site. Contrary to previous monitoring, the results identified only larger bat species in proximity to the nacelle at approximately 295 feet (90 meters) from ground level. Hoary bats (*Lasiurus cinereus*) and silver-haired bats (*Lasionycteris noctivagans*), both tree-roosting species, and the big brown bat (*Eptesicus fuscus*), a cave-roosting species, were the only species recorded. These recordings reflect the results of on-site mortality studies where these species were primarily found during mortality surveys.⁵
- Wildlife surveys were conducted at the STM wherein two amphibian species, two reptiles, 71 avian species, and 4 mammal species were recorded. Highlights include species not recorded previously, such as the Northern Pygmy-Owl (*Glaucidium californicum*).
- Tree Swallows (*Tachycineta bicolor*) returned to nest in two of the boxes along the eastern edge of a STM site detention basin.
- A pair of American Kestrels fledged a nestling at the STM site in a nest box provided by facilities maintenance (see photo p. 56).
- NREL staff installed four nest structures for Barn Swallows at the NWTC.
- NREL was featured on the DOE headquarters' Earth Day banner, along with the Pantex Plant and Hanford Site, for migratory bird protection efforts.
- The removal of a metal shed was delayed so that a resident bee hive could be removed and relocated at a time of year likely to protect the viability of the colony.
- NREL biologists hosted two nature walks for Earth Day.
- The Woodhouse's toad was seen during daytime surveys on the mesa top adjacent to ephemeral ponds in spring. Spring precipitation events determine the extent to which these ponds provide important aquatic habitat in the semi-arid climate of the STM site.
- NREL biology staff hosted and participated in a symposium panel discussion at the North American Wildlife Society on renewable energy and impacts to wildlife. This symposium was held at the Annual Wildlife Society Conference in Albuquerque, New Mexico.
- NREL biology staff hosted a local Audubon group and provided a tour of the NREL STM site to learn about bird-friendly building design and retrofits.
- NREL staff closed entry to the southeast stairwell of the STM site parking garage to protect fledgling birds (American Robin [*Turdus migratorius*] and Common Grackle [*Quiscalus quiscula*]).
- A Common Loon (*Gavia immer*) was found at the NWTC in November. Thought to be injured and unable to take flight, the loon was captured and taken to Greenwood Wildlife Rehabilitation Center. After examination, the loon did not appear injured and was taken that day to a reservoir and released.
- A roll-on grape extract was successfully used to repel Northern Flickers (*Colaptes auratus*) and prevent them from nesting in the façade of the Outdoor Test Facility. The repellent, which was applied monthly from March through May, was successful in reducing the overall number of holes initiated by the flickers.
- Raptor predator calls and decoys were used in the STM site parking garage stairwells to deter roosting pigeons; efforts appeared to be effective. Additionally, the stairwells were cleaned quarterly to further discourage pigeon roosting.
- An internal assessment of pest management practices was completed that resulted in non-conformities and opportunities for improvement regarding document control, maintaining an approved pesticide list, ensuring application records are consistently completed, and enhancing procedures for pesticide selection and application.

4. Two Dot Consulting, LLC. (2017). 2017 Vegetation and Wildlife Surveys at the National Renewable Energy Laboratory, South Table Mountain. Jefferson County, Colorado.

5. Tetra Tech EC, Inc. (2011). Avian Monitoring and Mortality Report, National Wind Technology Center. Jefferson County, Colorado.

1994 and 1995 that identified seven raptor species on or in the vicinity of the site. An avian survey was again completed in 2003 and updated in 2011. A 2016 survey included mammals, reptiles, amphibians, and terrestrial arthropods with results duplicating the 2011 survey that showed that various mammals, including elk, mule deer, coyotes, desert cottontail rabbits, bobcats, bats, deer mice, prairie voles, and shrews, continue to feed at and occupy the site. Although seldom seen, rattlesnakes, bull snakes, racers, and several other reptiles are also known to occupy the site. Amphibians, including boreal chorus frogs (*Pseudacris maculata*), Woodhouse's toad, and Northern leopard frog (*Lithobates pipiens*), occupy ephemeral wetlands at the NWTC.

A complete list of all wildlife species identified at both the STM site and the NWTC is found in Appendix C.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- Ground-nesting-bird surveys were conducted prior to annual mowing and weed control operations at the NWTC in conformance with the Migratory Bird Treaty Act. A Vesper Sparrow nest was found and cordoned off; mowing was delayed in that area until it was clear that the eggs had hatched and the young had permanently left the nest.

9.2 Endangered Species and Species of Concern

The federal Endangered Species Act 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. As a federal facility, NREL is

required to abide by the Endangered Species Act. Compliance ensures that the laboratory's actions do not adversely affect threatened, endangered, or candidate species that are listed under the Act. 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 U.S. Fish and Wildlife Service, which administers the Endangered Species Act, lists nine species as threatened, endangered, or a candidate for listing that could potentially be found in Jefferson and Boulder Counties. Of these species, three have the potential to occur at the STM site or the NWTC, including the Preble's meadow jumping mouse (*Zapus hudsonius preblei*), the Ute ladies' tresses orchid (*Spiranthes diluvialis*), and the Colorado butterfly plant (*Gaura neomexicana* var. *coloradensis*). According to the U. S. Fish and Wildlife Service iPac database, an additional 14 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 (CPW 2015), could also exist in Jefferson and Boulder Counties.

In 2017, a survey of the STM site did not detect any threatened, endangered, or species of concern. The 2016 NWTC 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 in order for a bird species to be counted as occupying the STM site or the NWTC, the bird could not simply be flying over the site but had to be stopping over or otherwise utilizing habitat at the site, such as by nesting or foraging.



A European Starling (*Sturnis vulgaris*) surveys the view from a meteorological tower at the NWTC. Photo by Lee Fingersh, NREL 50124



An American Kestrel (*Falco sparverius*) juvenile peeks from a nest box while the female looks on. Photo by Tom Ryan, NREL 49607

The U.S. Fish and Wildlife Service 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 southeast corner of the NWTC. This area may not be disturbed without prior coordination with the U.S. Fish and Wildlife Service.

Five other species, which occur in the Platte River watershed in Nebraska, are listed by the U.S. Fish and Wildlife Service 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 site and the NWTC NEPA environmental assessments conducted in 2014, DOE consulted with the U.S. Fish and Wildlife Service 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 U.S. Fish and Wildlife Service annually.

2017 Accomplishments and Highlights

- Wildlife biologists completed a survey at the STM site; no federally listed threatened, endangered, or species of conservation concern were found.
- NREL and DOE Golden Field Office staff supported three off-site ocean deployment projects where threatened and endangered species were present. Consultations with the National Marine Fisheries Service resulted in concurrence with a "Not Likely to Adversely Affect" determination. Project actions were identified and completed in such way to minimize impacts to the affected species.



Whooping Cranes (*Grus americana*) are endangered in the Central Flyway, including the Platte River Central Valley. Photo by Karin Sinclair, NREL 27963

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- No activities were conducted in designated critical habitat for the federally threatened Preble's meadow jumping mouse.
- The 23.9 million gallons (90.6 million liters) of water used at the STM site and the NWTC were reported to the U.S. Fish and Wildlife Service and fell below the agreed-upon limit of 39.5 million gallons (149.7 million liters) per year.

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 out-compete 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.

Native Landscaping – Landscaped areas near NREL buildings and common areas are designed to include 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



Aromatic sumac (*Rhus trilobata*) are found in upland shrublands on the STM site. Photo by Brent Nelson, NREL 23908

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 herbicide treatment. The effectiveness of control methods is periodically assessed. 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.

Comprehensive site-wide weed surveys and mapping are performed approximately every five years. Smaller areas of NREL’s main sites are assessed annually. A list of noxious weed species, as defined on the state’s noxious weed list, identified at the STM site and the NWTC is found in Table 7.

Table 7. Noxious Weed Species Identified at the STM Site and the NWTC^a

Noxious Weed Class	Species Present at STM	Species Present at NWTC
Class A ^b	Myrtle spurge	None
Class B ^c	Canada thistle Common teasel Dalmation toadflax Diffuse knapweed Hoary cress (whitetop) Hound’s tongue Musk thistle Russian olive Scotch thistle	Bull thistle Canada thistle Chicory Common teasel Dalmation toadflax Diffuse knapweed Hoary cress (whitetop) Moth mullein Musk thistle Sulfur cinquefoil
Class C ^d	Field bindweed Cheatgrass Common mullein	Field bindweed Cheatgrass Chicory Common mullein Common St. John’s wort

^aSpecies identified reflect findings of site-wide weed surveys performed in 2011 at the STM site and in 2016 at the NWTC.

^bIdentified by the state for eradication.

^cIdentified by the state to stop the spread.

^dIdentified by the state to more effectively manage on private and public lands through education, research, and biological control resources.

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 administered by the ESH&Q Office. This program includes wildfire assessments, fire risk management, and identifying areas of wildland-urban interface. These areas are currently being managed to achieve and maintain defensible space around buildings and other infrastructure against wildland fire. Most of the fire management activities of fire management can be done in conjunction with other vegetation management activities, such as weed control. Annual assessments of defensible space are conducted for the STM site and the NWTC.

Imported Plant and Organism Permits – An additional component of NREL’s vegetation management program relates to the use of certain animal and plant materials that are periodically used 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 U.S. Department of Agriculture 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. In 2017, NREL held three APHIS permits; two permits expired in the fall. Please see Appendix B for a listing of these permits.

2017 Accomplishments and Highlights

- Monthly review and coordination meetings were conducted to assess the success of seasonal herbicide applications and revegetation efforts.
- A vegetation survey was conducted at the STM site. No significant changes from previous surveys were identified.
- A vegetation and noxious weed survey report concluded that upland shrublands, composed primarily of mountain mahogany, experiences very limited regeneration due to cheatgrass (*Bromus tectorum*) competition.
- Annual herbicide spraying was performed to control of diffuse knapweed and sulfur cinquefoil (*Potentilla recta*) at the NWTC, and Canada thistle, houndstongue (*Cynoglossum officinale*), and myrtle spurge at the STM site.
- Weed mapping was performed at the STM site; the map will be used to plan future management actions.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- At the NWTC, herbicides were applied to approximately 345 acres (140 hectares) to control B- and C-listed weeds in May and June, as well as 10 acres (4 hectares) in September.
- At the STM site, herbicides were applied to control A-, B-, and C-listed weeds to approximately 40 acres (16 hectares) in April and May, including applications on the mesa top conservation easement; 12 acres (5 hectares) in June; and 5 acres (2 hectares) in August.
- NREL biologists introduced bindweed mites to combat bindweed on the STM site. Biological control specimens were provided by the Colorado Department of Agriculture State Insectary in Palisade, Colorado.
- The north and west sides of the RSF building were sprayed with a half-strength solution of Roundup®. This mixture selectively targets cheatgrass, a List-C noxious weed, that is first to emerge from dormancy in the late winter. Over the past three years this technique has increased the productivity of native grasses around the building.
- Herbicides were applied in April and May to a large tract (32 acres [13 hectares]) of grassland within the STM site conservation easement. The application targeted cheatgrass, dalmatian toadflax, and thistle.
- Russian olive trees were identified and mapped on the STM site during a natural resource inspection. The trees were treated with Roundup after girdling live branches, but a few tenacious trees are under consideration for “chainsaw treatment.”
- Through consistent monitoring and working with the Colorado Department of Agriculture, two additional noxious weed species were identified at the NWTC: sulfur cinquefoil and moth mullein (*Verbascum blattaria*). The invasive sulfur cinquefoil was treated in 2017 and treatments will continue in 2018. The slow-growing moth mullein will be incorporated in continuous plans to combat common mullein (*Verbascum thapsus*) as management practices for both species are similar.
- One new APHIS permit for the import of *Linum usitatissimum* (otherwise known as flax or linseed) stems from Canada was obtained. Two permits expired for napier grass (*Pennisetum purpureum*), sugarcane (*Saccharum officinarum*) bagasse, and sugarcane leaves and plant tops.

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 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 groundwater recharge. 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. Stream channels at NREL sites generally are more 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 8 lists the types and acreage of wetlands at the STM site and the NWTC that have been identified to date. Please refer to Appendix D for the locations of these wetlands.

NREL preserves 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 site and the NWTC.

Table 8. Wetland Types and Acreages at the STM Site and the NWTC

Wetland Type	STM Site (acres/ hectares)	NWTC (acres/ hectares)
Headwater	0.0 (0.0)	2.0 (0.9)
Palustrine Emergent ^a	1.3 (0.6)	3.6 (1.4)
Seasonal Pond	0.6 (0.2)	0.6 (0.2)
Wet Meadow	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.

2017 Compliance Summary and Activities

- Program activities were in compliance with regulations.
- New wetlands were observed in stormwater detention basins and drainageways on the STM site during vegetation surveys. These new wetlands contribute to the overall acreage in Table 8.



The “ammunition igloo” was constructed in 1940 as part of a Works Progress Administration project; the building is significant for its design. *Photo by David Parsons, NREL 06928*

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 site 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 site. Three historical resources were identified as significant cultural resources that should be preserved under the Archeological and Historic Preservation Act of 1974. These three resources, constructed in the 1930s and early 1940s during the Works

Progress Administration era, are located both at the STM site and at the remaining vestiges of Camp George West facilities and 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.

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

A formal survey of the NWTC was conducted in 1995⁶ and identified no significant historical or archeological resources.

2017 Accomplishments and Highlights

- An internal assessment was completed that resulted in three opportunities for improvement regarding management of collected items and associated records, clarification of procedures for Section 106 consultation, and enhancement of document control.

2017 Compliance Summary and Activities

- Program activities were in compliance with requirements.
- ESH&Q staff took baseline measurements of a crack in the STM ammunition igloo. The crack will be measured periodically to determine if the crack is expanding.
- A cultural resource review was conducted for a portion of the NWTC along the northwestern corner of the site where future utility line projects will occur. No cultural resources were found.

6. Labat-Anderson, Inc. (1995). Archaeological Assessment of the National Wind Technology Center. January 1995.



10 CONSERVATION LANDS

View to the west from the conservation easement at the STM site. *Photo by Kurt Schlomberg, NREL 50038*

In 1999, DOE granted a conservation easement of 177 acres (72 hectares) at the STM site to Jefferson County (see Figure 5).

A baseline inventory of the property was prepared in June 1999 to document the condition of the easement property and to assess its conservation value.⁷ 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 natural open space.

Local policies established by Jefferson County, Golden, and Lakewood reflect community sensitivity with respect to the visual qualities provided by natural resources in the area around the STM site. Specifically, the Jefferson County General Land Use Plan characterizes North and South Table Mountains as “unique landscapes” and states that “maintaining landscapes that have a unique visual quality” is key to maintaining the quality of life in Jefferson County.

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

Jefferson County Open Space maintains formal trails on the conservation easement property. Two trails cross the easement, connecting Denver West Parkway (near the STM site 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.

2017 Accomplishments and Highlights

- Conservation easement inspections were conducted in the summer and fall, and no new concerns were identified. In the prior year's inspection, it was noted that sections of fencing may have been limiting wildlife movement. Specific areas of fencing were identified and several sections were cut and rolled back to allow for wildlife to pass through. These areas were revisited and were found to support the movement of wildlife through the area.
- Since the August 2, 2016, 29-acre (11.8 hectares) wildfire, native grasses show moderate growth, especially in the northern half of the burn area. Areas of thin top soil, mostly in the southern portion, show strong regrowth of cheatgrass (*Bromus tectorum*), a Class-C noxious weed; no erosion has been observed as a result of the burn, likely due to its low intensity.
- Herbicides were applied in April and May to a large tract (32 acres [13 hectares]) of grassland within the STM site conservation easement. The herbicides targeted cheatgrass, dalmatian toadflax (*Linaria dalmatica*), and thistle (*Asteraceae* spp.).
- Russian olive trees (*Elaeagnus angustifolia*), an invasive species, were girdled to prevent their spread.
- Jefferson County Open Space conducted their annual assessment of the conservation easement. The resulting conservation easement Monitoring Report⁸ highlighted the significant natural features of the land parcel including wildlife habitat and unique landforms, as well as the passive recreational amenities provided by the public trails that cross the area. No significant changes to the land use and condition were observed from baseline observations.

8. Jefferson County Open Space Department, Jerry Bader. (2017). Conservation Easement Monitoring Report. August 2, 2016. Golden, Colorado.

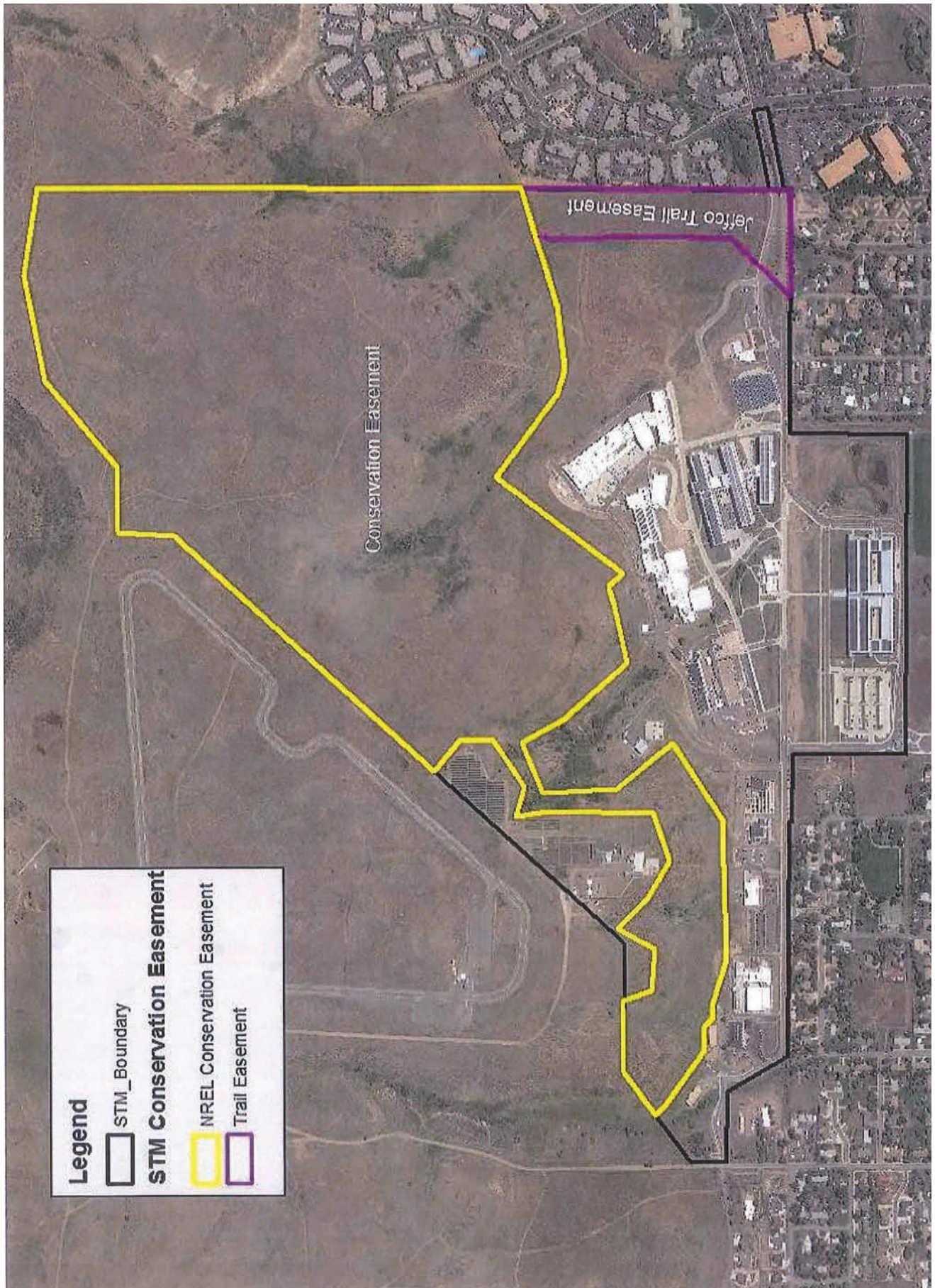


Figure 5. Conservation easement at the STM site



NREL celebrated its 40th anniversary in 2017.
Photo by Dennis Schroeder, NREL 45685

APPENDIX A. PROGRAM MANAGEMENT DESCRIPTIONS

Environmental Management Systems/ Pollution Prevention

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 at the laboratory; 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
- Maintaining accurate document records and controls
- Monitoring and performing corrective actions
- Conducting internal and external program assessments
- Maintaining adherence to the ISO 14001 standard.

The laboratory prevents pollution through the implementation of environmental and sustainability programs. This includes 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 greenhouse gas 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, engaging with the community, and employee culture change. 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 the development of renewable energy projects, overall laboratory reductions in 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 upon facility operations. NREL serves as both a living model of sustainability and a place to develop new clean energy ideas, technologies, and practices.

Climate Change Management

In 2014, NREL received funding from DOE's Sustainability Performance Office to develop a model process for climate change resilience planning, beginning its climate change management program. NREL worked with an outside research consultant, diverse stakeholders from across the laboratory, and key external stakeholders to conduct a vulnerability assessment and a resilience planning process. A steering committee composed of 22 staff members and smaller work groups with subject matter experts helped to identify climate-related sensitivities that could impact NREL's ability to meet its mission. These sensitivities were then scored using the most up-to-date climate science available for the region, and adaptation options for the highest-risk vulnerabilities were identified. This assessment process, which was also made available to other DOE sites, enabled NREL to develop a list of actions to manage near- and longer-term climate change risks. Each year the laboratory works to make progress on these action items.

Air Quality Protection

The objectives of NREL's air quality management 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 for "minor" sources (such as standby electrical generators and pollution control systems) that are subject to minimal permit and compliance requirements. Currently, Title V "major" permitting is not required because all pollutant emissions are well below that permitting threshold. An EPA Title V permit is required when one or more criteria emissions for a facility equals 100 or more tons per year (90.7 MT), or when the aggregate of all HAP emissions from any individual facility is more than 25 tons per year (22.7 MT).

The laboratory has a fugitive particulate emissions permit in place for the STM site due to construction activity that has occurred over the last several years. To further minimize the generation of airborne particulates, NREL uses a non-sand deicer to maintain roadways. This minimizes potential fugitive particulate emissions from snow removal operations, contributing to improved air quality for neighbors and the Denver metro region.

Greenhouse Gas Emissions Tracking and Permitting

Permitting and reporting of greenhouse gases are not currently required for NREL facilities as emissions are below EPA permitting and reporting thresholds. EPA requires that CO₂e equivalent (CO₂e) greenhouse gas emissions from any source which are larger than 27,500 U.S. tons per year (25,000 MT) be reported to EPA annually. EPA also requires a major source of criteria pollutants also include CO₂e emissions in the major source permit if CO₂e emissions exceed 75,000 tons per year (68,000 MT). NREL facilities are not major sources of criteria pollutants and CO₂e emissions for all facilities are less than either of the above-mentioned limits.

Ozone-Depleting Substances Permitting

The majority of refrigeration equipment at NREL either contains non-ODS refrigerants or uses very small amounts of regulated refrigerants. The only equipment containing more than 50 pounds (23 kilograms) of regulated refrigerants are two chillers located in the Solar Energy Research Facility at the STM site. Operators of the chillers must maintain records of service for this equipment.

Annually, NREL registers facilities where ODS maintenance activities occur, maintains EPA-approved training certification for all technicians servicing ODS-containing equipment, and renews registrations for ODS-containing equipment with the state as necessary. Both of the Solar Energy Research Facility chillers mentioned previously have more than 100 horsepower (74.6 kW) of compression, contain an ODS refrigerant, and must be registered with the state.

Drinking Water

Treated drinking water is provided to the STM site 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 NWTC, 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]) and 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 offsite 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 timeframe, 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 rain water and snowmelt, and prevent possible contamination of stormwater from exposure to materials stored outdoors. These objectives are accomplished through landscaping with native materials, revegetating site areas that have experienced a loss of vegetative cover, incorporating Low Impact Design elements in NREL design guidelines for new construction and redevelopment, and storing materials with the potential to contaminate stormwater either indoors or under cover.

Wastewater

NREL's wastewater management program is multi-faceted and encompasses activities across the site, from the use of green cleaning supplies to minimization of harmful chemicals in laboratory operations. The program addresses the requirements of the Metro Wastewater Reclamation District, which receives and treats waste from the STM site, and protects the groundwater aquifer to which the leach fields at the NWTC drain.

NREL has design guidelines for new building construction 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, prohibiting 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/or site
- Improving research efficiency and minimizing hazardous waste generation by allowing staff to determine if needed chemicals are already available on-site prior to making chemical purchases
- 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 help NREL to rigorously manage hazardous materials. Each week, safety personnel receive a list of the chemicals and their hazards that were shipped to NREL during the previous week. Researchers and safety personnel ensure that chemicals are properly stored in locations suitable for their hazards, such as 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 continues until material use is complete and it is ready for disposal. Hazardous materials proposed for use are also assessed for the potential substitution of less hazardous products, resulting in less 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:

- Documented waste management and minimization program
- Annual training for all staff members who generate and/or handle regulated waste
- Regular inspection and tracking of all waste containers
- Storage, packaging, shipment, and tracking until final disposition at a properly permitted waste disposal or recycling facility
- Active monitoring of waste volumes to determine generator status
- Maintaining 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 non-hazardous materials are collected and disposed of as non-hazardous materials at properly permitted disposal facilities. For example, non-hazardous, nanomaterial-bearing wastes are not federally regulated but, because they pose a potential health risk, are managed and disposed of using the same management methods used for hazardous waste. Waste streams are accumulated on site for timeframes well within regulatory limits prior to 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 permit compliance, inspections, tank maintenance and improvements, training, and spill response.

Staff actively participate in the program through:

- 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-wall tanks equipped with sensors that result in an alarm if the inner tank wall is leaking, and secondary containment for single-wall 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 liters) are visually inspected monthly and all double-walled ASTs are inspected annually to confirm that 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 NWTC, the STM site, 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 there is a significant change in regulations, operations, or equipment.

This aggressive approach to spill prevention and control exceeds the EPA's requirement that SPCC plans be updated at least every 5 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 also includes inspection and response requirements, location and use of spill response equipment, and notification and spill reporting protocols.

The laboratory typically does not experience spills that require notification to federal and state agencies. Small, incidental hydraulic system leaks, lubricant leaks, and fuel transfer spills may occur on occasion. Lessons learned from spill incidents and clean-up activities are used to improve management and spill response planning.

Radiological Materials

Through its radiation safety program, NREL has established strict protocols for radiation-generating devices, equipment containing sources of radiation, and for 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 also federally regulated under the Resource Conservation and Recovery Act 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 this 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 Golden Field Office use Site-Wide Environmental Assessments (EAs) to streamline the environmental review process. These documents are comprehensive analyses of potential environmental impacts associated with NREL's current and future actions over 5–10 years at both the STM site and the NWTC. The EAs 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 site and the NWTC 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 but 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 proposed activities have not already been evaluated in an existing Site-Wide EA or Programmatic NEPA Determination,

then 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 while pursuing NREL's mission. 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 U.S. Fish and Wildlife Service to promote the conservation of migratory bird populations, and a presidential memorandum to promote the health of honey bees and other pollinators.

Several activities occur to achieve the program's intent including the following:

Monitoring – The laboratory conducts nesting bird surveys prior to any ground- or vegetation-disturbing activities conducted between mid-March and mid-September every year. If nests are found, the area is closed and a buffer area established until nestlings fledge. Staff also conduct site-wide surveys on a periodic basis to document biological conditions at NREL facilities.

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 site by retaining access to the adjacent conservation easement north of the site and Pleasant View Community Park and Lena Gulch to the south. At the NWTC, 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. 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 NWTC and STM site to determine the presence/absence of species that are listed under the federal Endangered Species Act 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 (*Oenothera coloradensis*). To date, none of these species have been identified at either of NREL's main sites. Species listed by the U.S. Fish and Wildlife Service on the iPac site as species of special concern, as well as species listed by the state of Colorado as rare plants, species of concern, or species of greatest conservation concern are surveyed along with the federally listed species. These baseline surveys, which are typically conducted every five years, are a vital part of NREL's NEPA program through which impacts to natural resources from mission activities are assessed.

The U.S. Fish and Wildlife Service designated critical habitat associated with the Preble's meadow jumping mouse within the upper reaches of Rock Creek, including a small area at the southeast corner of the NWTC. This area may not be disturbed without coordination with the U.S. Fish and Wildlife Service.

In accordance with the Endangered Species Act, the U.S. Fish and Wildlife Service 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 (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*]). For any NREL activities that may deplete water in the Platte River system, consultation with the U.S. Fish and Wildlife Service 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 non-invasive 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 environment.

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

NREL participated in the Sustainable Sites Initiative two-year pilot program (2010-2012) established by the American Society of 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 purpose of the pilot program was to develop the first national rating system for sustainable landscapes. Certification under the program demonstrates that the stewardship activities necessary 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 program is also 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 hand pulling), cultural (e.g., reclamation of disturbed areas), prevention (e.g., limiting or eliminating driving of vehicles off established roadways), and herbicide treatment. The effectiveness of control methods is periodically assessed. 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 assists in targeting weed control efforts.

The laboratory continues to address the control of these species using the integrated weed management approach described above. 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 site and the NWTC, vegetation management is balanced with maintaining native vegetation and wildlife habitat. At the NWTC, water tanks are inspected regularly to ensure that firefighting resources are available should a wildfire occur.

Imported Plants and Organisms

NREL's vegetation management program also addresses the use of certain animal and plant species brought to the laboratory for research purposes, primarily associated with biofuels and biomaterials investigations. Some of these animals (pathogens) and plant species obtained from other states or from outside the United State are controlled by the U.S. Department of Agriculture's Animal and Plant Health Inspections Service (APHIS) and require permitting to protect against their release into both the immediate work area and to the outside environment. In addition to the required management practices identified in APHIS-issued permits, management of these materials are 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 through several means:

- Periodically surveying vegetation and wetland delineations
- Mapping of wetland areas potentially affected by proposed construction

- Identifying potential impacts
- Coordinating with other jurisdictions on the control of floodwaters leaving NREL's STM site and the NWTC.

The U.S. Army Corps of Engineers has examined the STM site drainages and determined that they do not fit jurisdictional wetland criteria and are not currently regulated. The U.S. Army Corp of Engineers has not evaluated the NWTC site drainages to date. Functional wetlands, whether regulated or not, are considered valuable features that serve many ecological functions, and the laboratory seeks to preserve these to the maximum extent practicable from site development structures.

Cultural Resources

Cultural resources are protected at NREL in several ways:

- Integrating cultural resource management into site activities and minimizing and/or mitigating impacts to historic properties and features
- Implementing procedures to manage historic features and to 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 in the event any evidence of cultural resources is discovered during surveys or ground-disturbing activities. Workers are to stop all work in the vicinity until a qualified archaeologist evaluates the significance of the find.

Conservation Lands

Approximately 177 acres (72 hectares) at the STM site 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 NWTC, approximately 60 acres (24 hectares) of land are managed as a conservation area. Development is limited in this area, and it is managed to conserve specific features including seeps, ephemeral drainages, ponds, native grassland habitat, areas supporting ancient soils (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, an area of remnant tallgrass prairie, 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 Alexis Powers, NREL 23815*

Table 9. NREL'S Environmental Permits, Registrations, and Notifications in 2017

NREL'S ENVIRONMENTAL PERMITS, REGISTRATIONS, AND NOTIFICATIONS IN 2017					
Type	Location/ Description	Category	Issuing Agency	ID #	Permit or Registration Status
AST for petroleum storage	STM ESIF AST	Registration	DOPS	19275-1	Completed
AST for petroleum storage	STM PDU AST	Registration	DOPS	2873-2	Completed
AST for petroleum storage	STM RSF2 AST	Registration	DOPS	19211-1	Completed
AST for petroleum storage	STM SERF AST	Registration	DOPS	2873-1	Completed
AST for petroleum storage	E85 AST	Registration	DOPS	2873-4	Completed
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'S ENVIRONMENTAL PERMITS, REGISTRATIONS, AND NOTIFICATIONS IN 2017

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	NWTC Site 4.0 diesel-fired standby electrical generator	Permit	APCD	10JE1712	Active
Air	STM parking garage diesel-fired standby electrical generator	Permit	APCD	11JE1997	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 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	APEN	APCD	13JE2276 XP	Active
Air	NWTC STL standby electrical generator	APEN	APCD	13JE2271 XP	Active
Air	NWTC Building 251 standby electrical generator	APEN	APCD	13JE2272 XP	Active
Air	NWTC Composites Manufacturing Education and Technology facility composite demonstration facility	APEN	APCD	16JE0934	Active
Alcohol	STM IBRF alcohol fuel production	Permit	TTB	AFP-CO-00255	Active
Alcohol	STM tax-free alcohol use	Permit	TTB	TF-CO-0331	Active

NREL'S ENVIRONMENTAL PERMITS, REGISTRATIONS, AND NOTIFICATIONS IN 2017

Type	Location/ Description	Category	Issuing Agency	ID #	Permit or Registration Status
Animals, Plants	CIP to import flax (<i>Linum usitatissimum</i>) from Canada	Permit	APHIS	PCIP-17-00534	Active
Animals, Plants	CIP to import <i>Agrobacterium tumefaciens</i> from within the U.S.	Permit	APHIS	P526P-16-03695	Active
Animals, Plants	CIP to import <i>Goronia</i> , <i>Aquitalea</i> , <i>Cupriavidus</i> , <i>Gulbenkiana</i> , <i>Novosphingobium</i> , <i>Pseudogulbenkiana</i> , <i>Roseatles</i> from Puerto Rico or U.S. Virgin Islands	Permit	APHIS	P526-16-00476	Active
Animals, Plants	CIP to import Napier grass (<i>Pennisetum</i> spp.), Sugarcane (<i>Saccharum officinarum</i>) bagasse from Japan, Columbia and other countries	Permit	APHIS	PCIP-15-01301	Expired
Animals, Plants	CIP to import Sugarcane leaves and plant tops from Brazil and other countries	Permit	APHIS	PCIP-16-00369	Expired
Drinking water system	NWTC 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	11408	Active
Hazardous materials	STM SERF hazardous material storage and use permit	Permit	WMFR	11412	Active
Hazardous materials	STM S&TF hazardous material storage and use permit	Permit	WMFR	11413	Active
Hazardous materials	STM FTLB hazardous material storage and use permit	Permit	WMFR	11409	Active
Hazardous materials	STM IBRF hazardous material storage and use permit	Permit	WMFR	11410	Active

NREL'S ENVIRONMENTAL PERMITS, REGISTRATIONS, AND NOTIFICATIONS IN 2017

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	11411	Active
Hazardous materials	DWOP building 16 hazardous material storage and use permit	Permit	WMFR	11407	Active
Hazardous materials	ReFUEL hazardous material storage and use permit	Permit	Denver Fire Department	165636	Active
Hazardous waste	DWOP 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
Hazardous waste	NWTC 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 electrical upgrade project	Permit	EPA	COR12B06F	Terminated
Stormwater	STM SERF & S&TF Landscape Improvements/Site Improvements	Permit	EPA	COR10F00K	Active
Stormwater	NWTC Site Improvements, Power Generation Upgrade, and Secondary Feeder	Permit	EPA	COR10F028	Active

Acronyms used in the table:

APCD	Air Pollution Control Division of CDPHE	JSF	Joyce Street Facility
APEN	Air Pollutant Emission Notice		
APHIS	Animal and Plant Health Inspection Service of the U.S. Department of Agriculture	NPS	National Park Service of the U.S. Department of the Interior
AST	Aboveground Storage Tank	NWTC	National Wind Technology Center
CDPHE	Colorado Department of Public Health and Environment	PDU	Process Development Unit
CFC	Chlorofluorocarbon		
CIP	Controlled Import Permit	RCRA	Resource Conservation and Recovery Act
		ReFUEL	Renewable Fuels and Lubricants Research Laboratory
DFD	Denver Fire Department	RFHP	Renewable Fuel Heat Plant
DOPS	Division of Oil and Public Safety of the Colorado Department of Labor and Employment	RSF	Research Support Facility
DWOP	Denver West Office Park		
DWR	Colorado Division of Water Resources	S&TF	Science and Technology Facility
		SERF	Solar Energy Research Facility
EPA	Environmental Protection Agency	STM	South Table Mountain
ESIF	Energy Systems Integration Facility		
		TTB	Alcohol and Tobacco Tax and Trade Bureau of the U.S. Department of the Treasury
FTLB	Field Test Laboratory Building		
		WHF	Waste Handling Facility
HMWMD	Hazardous Materials and Waste Management Division of CDPHE	WMFR	West Metro Fire Rescue
		WQCD	Water Quality Control Division of CDPHE
IBRF	Integrated Biorefinery Research Facility		



APPENDIX C. WILDLIFE SPECIES OBSERVED AT THE STM SITE AND THE NWTC

A female Red-winged Blackbird (*Agelaius phoeniceus*) utilizing the wetland habitat in the STM site's main detention basin. Photo by Dennis Schroeder, NREL 45399

The following are lists of common and scientific names of wildlife species observed at the STM site and the NWTC. The species listed for the STM site were observed by staff and/or observed in surveys completed in 1987, 2005, 2011, and 2017. For 1987 survey results, please refer to NREL's 2016 Environmental Performance Report at: <https://www.nrel.gov/docs/fy17osti/68671.pdf>. The species for the NWTC were identified during surveys completed in 1996, 2003, 2011, and 2016. For 1996 survey results, please refer to NREL's 2015 Environmental Performance Report at: <https://www.nrel.gov/docs/fy16osti/65807.pdf>.

Table 10. Wildlife Species at the STM Site

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

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

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

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

Species Common Name	Scientific Name	2005 Survey	2011 Survey	2017 Survey
MAMMALS				
Big brown bat ^a	<i>Eptesicus fuscus</i>			
Black bear ^a	<i>Ursus americanus</i>			
Black-tailed jackrabbit	<i>Lepus californicus</i>		X	
Bushy-tailed woodrat	<i>Neotoma cinerea</i>			
Coyote	<i>Canis latrans</i>	X	X	
Deer mouse	<i>Peromyscus maniculatus</i>		X	
Elk ^a	<i>Cervus canadensis</i>			
Fox squirrel	<i>Sciurus niger</i>	X		
Hoary bat	<i>Lasiurus cinereus</i>			X
Long-tailed weasel	<i>Mustela frenata</i>	X		
Mexican woodrat	<i>Neotoma mexicana</i>	X	X	
Mountain cottontail	<i>Sylvilagus nuttalli</i>	X	X	
Mule deer	<i>Odocoileus hemionus</i>	X	X	
Prairie vole	<i>Microtus ochrogaster</i>	X		
Raccoon	<i>Procyon lotor</i>	X	X	
Red fox	<i>Vulpes vulpes</i>		X	
Striped skunk	<i>Mephitis</i>		X	
Western harvest mouse	<i>Reithrodontomys megalotis</i>	X	X	
Western spotted skunk	<i>Spilogale gracilis</i>		X	
White-tailed jackrabbit	<i>Lepus townsendii</i>	X		
Yellow-bellied marmot	<i>Marmota flaviventris</i>			
REPTILES AND AMPHIBIANS				
Bull snake	<i>Pituophis catenifer</i>		X	
Plains garter snake	<i>Thamnophis radix</i>	X		
Prairie lizard	<i>Sceloporus undulatus</i>		X	
Racer	<i>Coluber constrictor</i>		X	
Six-lined racerunner	<i>Cnemidophorus sexlineatus</i>	X		
Tiger salamander	<i>Ambystoma tigrinum</i>	X	X	X
Western chorus frog	<i>Pseudacris triseriata</i>		X	
Western (Prairie) rattlesnake	<i>Crotalus viridis</i>	X	X	
Woodhouse's toad	<i>Bufo woodhousii</i>		X	

^aSpecies observed at a time other than during a survey

Table 11. Wildlife Species at the NWTC

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

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Eurasian Collared-Dove	<i>Streptopelia decaocto</i>		X	
European Starling	<i>Sturnus vulgaris</i>	X	X	X
Ferruginous Hawk	<i>Buteo regalis</i>	X	X	
Franklin's Gull	<i>Larus pipixcan</i>		X	
Golden Eagle	<i>Aquila chrysaetos</i>	X	X	
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	X	X	X
Gray Catbird	<i>Dumetella carolinensis</i>		X	X
Great Blue Heron	<i>Ardea herodias</i>	X	X	X
Great Horned Owl	<i>Bubo virginianus</i>		X	X
Greater Roadrunner ³	<i>Geococcyx californianus</i>			
Green-tailed Towhee	<i>Pipilo chlorurus</i>	X		X
Hairy Woodpecker	<i>Picoides villosus</i>		X	
Horned Lark	<i>Eremophila alpestris</i>	X	X	
House Finch	<i>Carpodacus mexicanus</i>	X	X	X
House Wren	<i>Troglodytes aedon</i>			X
Killdeer	<i>Charadrius vociferus</i>		X	X
Lark Bunting	<i>Calamospiza melanocorys</i>		X	
Lark Sparrow	<i>Chondestes grammacus</i>	X		X
Loggerhead Shrike	<i>Lanius ludovicianus</i>		X	
Long-billed Curlew	<i>Numenius americanus</i>		X	
Mallard	<i>Anas platyrhynchos</i>	X	X	
Merlin	<i>Falco columbarius</i>			
Mountain Bluebird	<i>Sialia currucoides</i>	X	X	
Mountain Chickadee	<i>Poecile gambeli</i>		X	
Mourning Dove	<i>Zenaida macroura</i>	X	X	X
Northern Flicker	<i>Colaptes auratus</i>	X	X	
Northern Goshawk	<i>Accipiter gentilis</i>			
Northern Harrier	<i>Circus cyaneus</i>	X	X	
Osprey	<i>Pandion haliaetus</i>			
Peregrine Falcon	<i>Falco peregrinus</i>	X	X	
Prairie Falcon	<i>Falco mexicanus</i>	X		
Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>		X	

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Red-tailed Hawk	<i>Buteo jamaicensis</i>	X	X	X
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	X	X	X
Rough-legged Hawk	<i>Buteo lagopus</i>	X	X	
Ruby-crowned Kinglet	<i>Regulus calendula</i>		X	
Sandhill Crane	<i>Grus canadensis</i>		X	
Savannah Sparrow	<i>Passerculus sandwichensis</i>		X	
Say's Phoebe	<i>Sayornis saya</i>	X	X	X
Sharp-shinned Hawk	<i>Accipiter striatus</i>			
Song Sparrow	<i>Melospiza melodia</i>		X	X
Spotted Towhee	<i>Pipilo maculatus</i>		X	X
Swainson's Hawk	<i>Buteo swainsoni</i>		X	
Townsend's Solitaire	<i>Myadestes townsendi</i>		X	
Tree Swallow	<i>Tachycineta bicolor</i>		X	
Turkey Vulture	<i>Cathartes aura</i>	X	X	
Vesper Sparrow	<i>Pooecetes gramineus</i>	X	X	X
Western Kingbird	<i>Tyrannus verticalis</i>	X	X	X
Western Meadowlark	<i>Sturnella neglecta</i>	X	X	X
Western Wood Peewee	<i>Contopus sordidulus</i>			X
Wilson's Snipe	<i>Gallinago delicata</i>			X
Wilson's Warbler	<i>Wilsonia pusilla</i>	X		
Yellow-rumped Warbler	<i>Dendroica coronata</i>	X		
MAMMALS				
Big brown bat	<i>Eptesicus fuscus</i>		X	X
Black-tailed prairie dog ^a	<i>Cynomys ludovicianus</i>	X		
Bobcat	<i>Felis rufus</i>			X
Coyote	<i>Canis latrans</i>		X	X
Deer mouse	<i>Peromyscus maniculatus</i>		X	X
Desert cottontail	<i>Sylvilagus audubonii</i>		X	X
Eastern red bat	<i>Lasiurus borealis</i>		X	X
Elk	<i>Cervus canadensis</i>		X	X
Fringed myotis ^b	<i>Myotis thysanodes</i>		X	X
Hoary bat	<i>Lasiurus cinereus</i>		X	X
Little brown myotis ^b	<i>Myotis lucifuaus</i>		X	X

Species Common Name	Scientific Name	2003 Survey	2011 Survey	2016 Survey
Masked shrew	<i>Sorex cinereus</i>		X	X
Meadow vole	<i>Microtus pennsylvanicus</i>		X	X
Mexican woodrat	<i>Neotoma mexicana</i>		X	X
Mountain lion	<i>Puma concolor</i>			X
Mule deer	<i>Odocoileus hemionus</i>		X	X
Myotis bat	<i>Myotis sp.</i>		X	X
Prairie vole	<i>Microtus ochrogaster</i>		X	X
Silver-haired bat	<i>Lasiorycteris noctivagans</i>		X	X
Thirteen-lined ground squirrel	<i>Spermophilus tridecemlineatus</i>		X	
Western harvest mouse	<i>Reithrodontomys megalotis</i>		X	X
White-tailed deer	<i>Odocoileus virginiana</i>			X
REPTILES AND AMPHIBIANS				
Boreal chorus frog	<i>Pseudacris maculata</i>		X	X
Bull snake	<i>Pituophis catenifer</i>		X	X
Northern leopard frog ^b	<i>Lithobates pipiens</i>			X
Tiger salamander	<i>Ambystoma tigrinum</i>			X
Western (Prairie) rattlesnake	<i>Crotalus viridis</i>	X	X	X
Woodhouse's toad	<i>Bufo woodhousii</i>		X	X
TERRESTRIAL ARTHROPODS^c				
Aphrodite fritillary	<i>Speyeria aphrodite</i>		X	
Cabbage white	<i>Pieris rapae</i>		X	
Checkered white	<i>Pontia protodice</i>		X	
Common wood nymph	<i>Cercyonis pegala</i>		X	
Dainty sulphur	<i>Nathalis iole</i>		X	
Gray hairstreak	<i>Strymon melinus</i>		X	
Orange sulphur	<i>Colias eurytheme</i>		X	
Western white	<i>Pontia occidentalis</i>		X	

^aSpecies observed at a time other than during a survey

^bColorado State Species of Highest Conservation Need, Tier 1

^cTerrestrial arthropod genera of specific concern were only surveyed in 2011 at the NWTC.



An American vetch (*Vicia americana*) at the STM site.
Photo by Brent Nelson, NREL 23877

APPENDIX D. PLANT COMMUNITIES AT THE STM SITE AND THE NWTC

Vegetation surveys are periodically completed for the STM site and the NWTC, with the most recent surveys occurring at the STM site in 2017 and at the NWTC 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

The majority of vegetation at the STM site belongs to the grassland community type. Within that association, there are two distinct community types: short grassland on the mesa top and mixed grassland located on the mesa slopes and toe areas. Other mapped vegetation communities at the STM site include ravine shrubland, tall shrubland, short shrubland, and wetlands. The plant communities are described below and mapped as illustrated in Figure 6.

Short Grassland

Short grassland is found on the flat top of the mesa. The dominant grass species are blue grama (*Chondrosom 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. *vivipara*). 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*) occur 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, this short grassland 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 out-competing native plants.

Mixed Grassland

The mesa slopes and toe areas on the STM site 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 occur 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 located on a southern-facing slope, near the eastern property boundary. The other is located on a southwestern-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 (one meter and larger) 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 the majority 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 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, becoming 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, 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*), often growing 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 southeast 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 site were found to support wetland vegetation. These communities were not 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 half an acre 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 past construction activities. This linear depression supports wetland vegetation

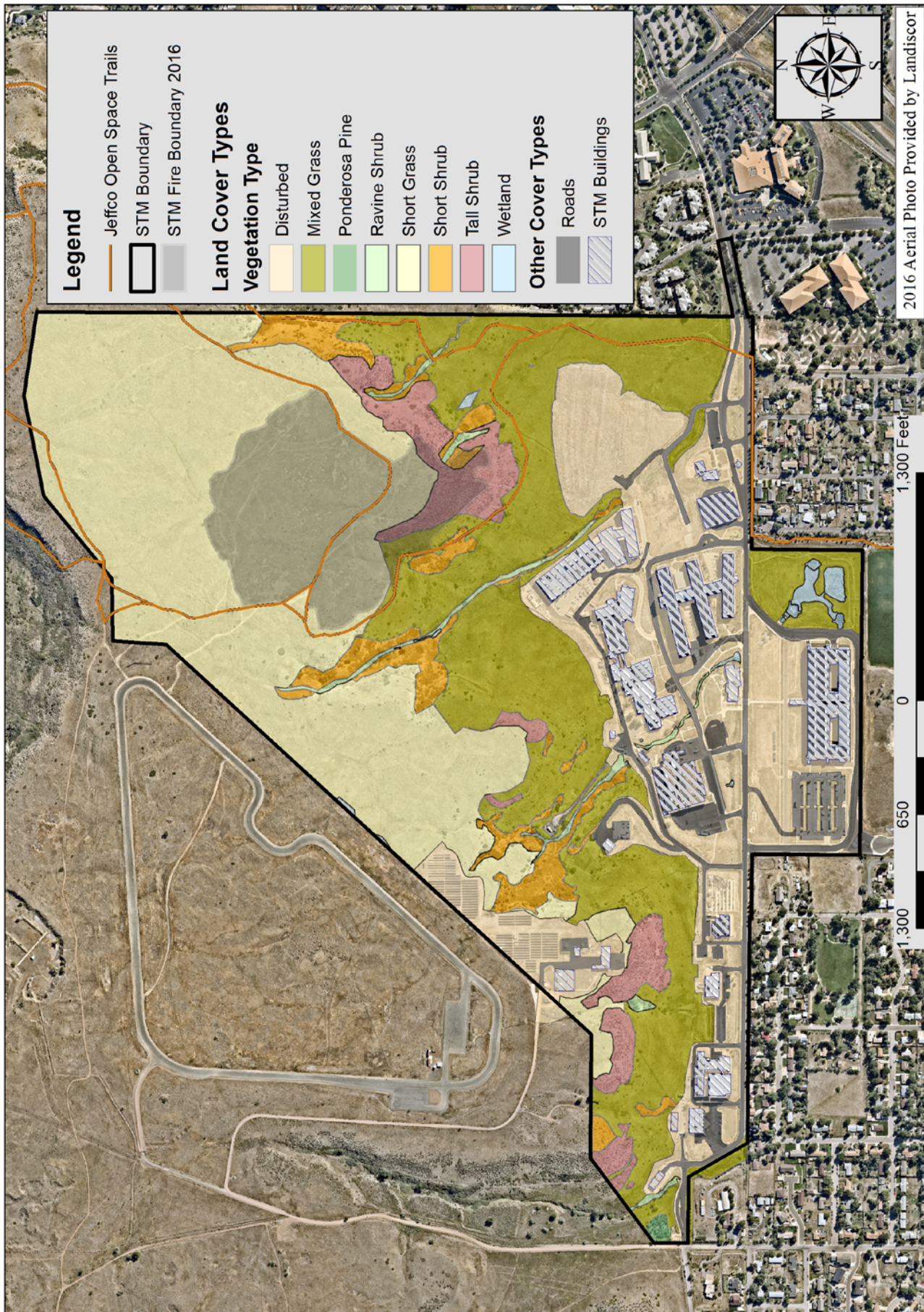


Figure 6. STM site land cover types surveyed in 2017.

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 hill slope between the NREL Education Center and the public trail on the far eastern boundary of the site. These seeps are dominated with sedges, rushes, and Canada thistle (*Cirsium arvensis*).

A seventh wetland community that was observed⁹ 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 re-vegetated and support a combination of native grassland plants, planted ornamental re-vegetation species, and native and introduced weeds.

NWTC Plant Communities

The majority of the vegetation at the NWTC 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 (*Chondrosium gracile*) and buffalograss (*Buchlōe 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 NWTC fall into the xeric mixed-grassland community type identified and classified primarily on available soils and soil moisture, reflected in xeric mixed-grassland plant species assemblages.

A number of changes in vegetation patterns noted since the NWTC was previously mapped is discussed below by specific plant community. In addition, the plant communities are described and mapped as illustrated in Figure 7.

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 NWTC and 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 (*Psoraleidum tenuiflorum*), and hairy golden aster (*Heterotheca villosa*). Native grasses within this community, particularly big bluestem and switchgrass, occur most frequently along roadside depressions, possibly due to higher soil moisture from captured precipitation runoff.

Disturbed Native Grassland

This community occurs along the northern fence line of NWTC. Total vegetative cover in this community ranges from 30%–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 that this area has been significantly disturbed by human activity. However, this community had the highest vegetative cover of native grasses within NWTC. 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*).

9. 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; however, 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 NWTC. 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. Near the southwest corner of the NWTC is an area containing 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 on recent aerial imagery. The degraded grassland community along the western boundary of the NWTC is possibly influenced by historic 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 project area. 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*), sulphur cinquefoil (*Potentilla recta*), golden banner (*Thermopsis rhombifolia*), harebell (*Campanula rotundifolia*), and James' nailwort (*Paronychia jamesii*).

Mixed Shrubland

The mixed shrubland community occurs on the southeast end of the same granite outcrop that supports the ponderosa pine woodland. The southeast 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 NWTC site boundary. These trees are at the top of the slope and occur directly east of an active area of construction disturbance, which is outside the NWTC boundary.

Palustrine Emergent Wetland

Six wetlands were identified at the NWTC that fall into the palustrine emergent category.¹⁰ 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 (PEM) occurs south of the solar array in Row 1. The southernmost road separates this large wetland from a second smaller wetland located along the southern fence line of the NWTC. These wetlands appear to be hydrologically connected and supported by seepage from a reservoir located 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 consultant¹¹; however, another consultant¹² mapped this area as "mixed mesic grassland" dominated by big bluestem. Hydrological support has evidently increased since 2011 as this area was dominated by obligate wetland species and surface water was present throughout the area during the 2016 field surveys.

A second large PEM occurs in a seasonal pond located southwest of the ponderosa pine woodland community. A consulting firm¹² 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

10. 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.

11. Plantae Consulting Services. (2000). Vegetation Survey, NREL National Wind Technology Center. Boulder, CO.

12. Walsh Environmental Scientists and Engineers. (2011a). 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.

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 PEM occurs south of the solar array in Row 3. 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 PEMs occur on slopes along the northern boundary of the project area. The first PEM is located in the northwest corner of NWTC, and the second occurs along the northern fence line adjacent to the parking lot of the administration and engineering building. 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 ground water seeps. Both of these wetlands were previously identified and mapped.

Headwater – Riparian Emergent Wetland

Headwater or riparian emergent wetland communities occur within the two prominent drainages located in the eastern half of NWTC (Figure 7). Both drainages show evidence of intermittent flow. The northernmost drainage is 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 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 grass and 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. The 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.)

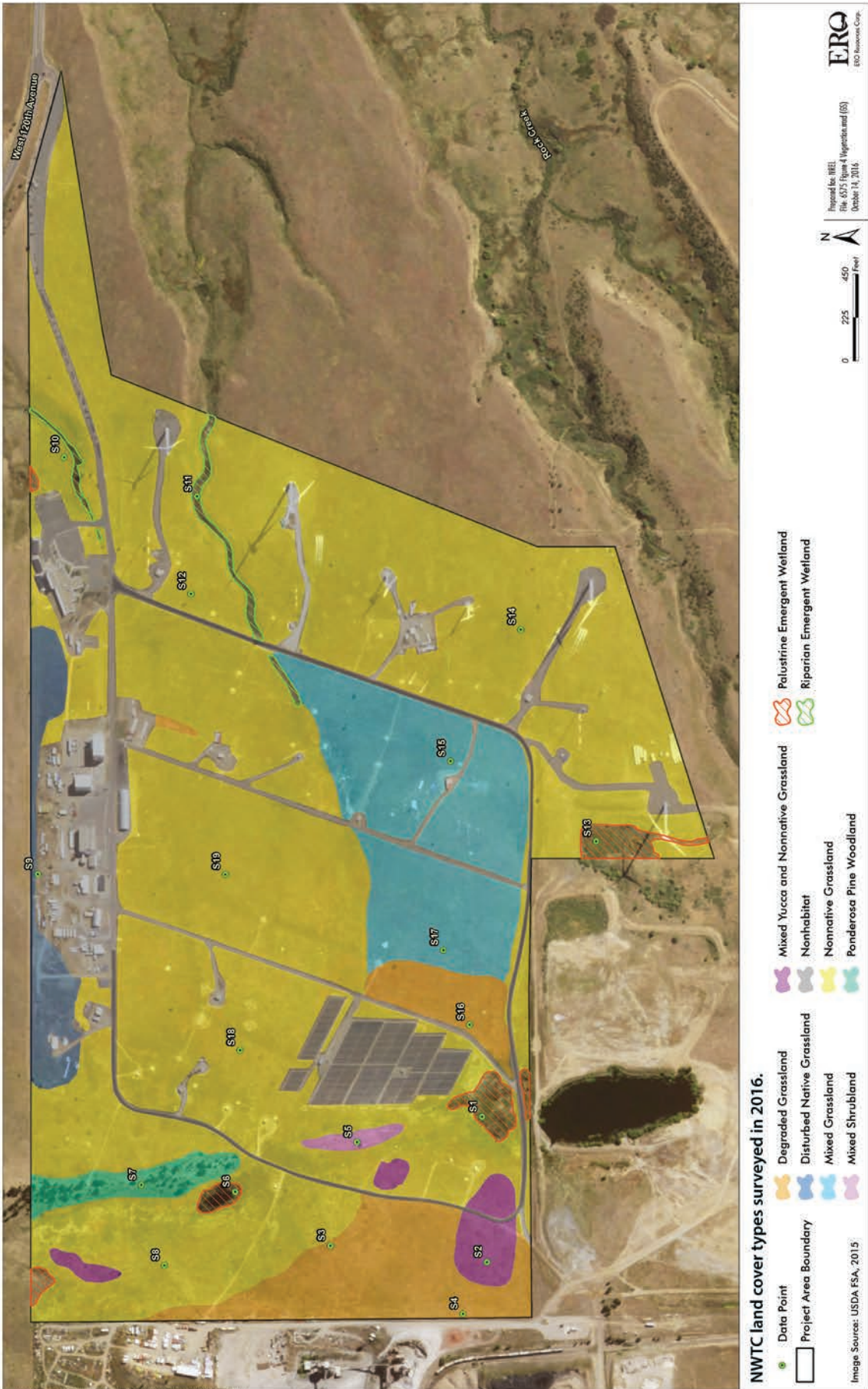


Figure 7. NWTC land cover types surveyed in 2016



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