Annual Report on Technology Transfer

FY 2023 Activities

U.S. Department of the Interior

Description of Cover Photos

Upper Left: A field of wind turbines in Wyoming with a storm rolling in. Photo: Paul Cryan, USGS

Upper Right: The chemical compound known as 6PPD is present in all tires on U.S. roads, but exposure to ozone converts it into a toxic substance that harms aquatic species such as salmon. USGS is working to find an alternative to 6PPD. Photo: BLM

Lower Left: Elastec Kvichak vessel with an X30 grooved disc skimmer collecting dielectric fluid in a test pool. This technology is designed to help recover pollutants discharged from offshore wind turbines. Photo: BSEE

Lower Right: Shasta Dam on the Sacramento River. Reclamation projects like Shasta Dam provide water, power, recreation, and flood protection to millions of Americans. Photo: Bureau of Reclamation

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I. Executive Summary

This report identifies and describes how the Department of the Interior (Interior, Department) advanced technology transfer in Fiscal Year (FY) 2023. These activities demonstrate the innovation, expertise, and dedication of Departmental employees to help reduce risks to public health, safety, and the environment, and to honor Federal trust and treaty responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

During FY 2023, the Department continued to engage in a broad range of cooperative technology transfer activities – 34 cooperative research and development agreements (CRADAs), 1,669 other cooperative research and development (R&D) activities, 10 new invention disclosures, two new invention licenses, and over 3,400 publications – to achieve key outcomes including:

- To improve public knowledge and scientific understanding of renewable energy resources, the Department developed an expansive database of wind turbine locations across the Nation.
- To monitor and combat the spread of invasive species, the Department developed methods for detecting free-floating "environmental DNA" (environmental DNA or eDNA) in water samples to confirm the presence or absence of these.
- To provide greater transparency into the restoration of abandoned mine lands, the Department released an updated public mapping system for restoration sites with expanded access to cost and project status data.
- To protect air quality for park visitors and the public, the Department participated in a CRADA with the State of Texas to operate an air quality monitoring station in Big Bend National Park, producing valuable data on air pollution and weather conditions.
- To reduce wear and tear on Federal dams and hydraulics, the Department entered a CRADA for hydrological research that will detect water cavitation, a process in which bubbles or voids form in water and damage equipment, and help operators avoid the conditions that cause it.
- To aid in the cleanup of oil spills at sea, the Department researched the use of sensor technology to detect and measure the size distribution of oil droplets in water depths of one to five meters, helping recovery workers determine where to deploy oil collection and dispersal technologies.
- To reduce the environmental impacts of offshore energy development, the Department launched two studies on the propagation of sound through the ocean floor and its effects on the behavior of marine wildlife.

- To monitor and protect the health of the Nation's public rangelands, the Department collected 6,725 geographic and ecological data points from upland, river, stream, riparian and wetland systems, calculated indicators of rangeland health, and shared them with the public.
- To protect communities and ecosystems from wildfire in a warming world, the Department and partner agencies funded eight research studies to determine the long-term effectiveness of fuel reduction treatments under climate change, helping fire managers determine which and how many such treatments are needed to control wildfires.

II. Introduction

Each year, technology transfer at Interior advances the goals of the Technology Transfer Commercialization Act of 2000. In FY 2023, the Department strengthened the Nation's competitive ability in the global marketplace; furthered collaboration among government, industry, and universities that carry out the scientific enterprise; and improved the quality of life for the American people. Achieving these goals also helped advance Interior's mission:

- To protect and manage the Nation’s natural resources and cultural heritage;
- To provide scientific and other information about those resources; and
- To honor our trust and treaty responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The FY 2023 report shares examples of technology transfer activities at the Department in three categories:

- Publishing and exchanging scientific and technical information;
- Protecting and licensing intellectual property rights; and
- Sharing specialized scientific material and resources that the Department manages.

The report is the result of a cooperative effort by Interior’s Departmental Working Group on Technology Transfer, which is coordinated by the Department’s Office of Policy Analysis. The working group, which included bureau and office personnel involved with their respective research and development programs, provided the underlying data. Interior prepared this report using data compiled according to the most recent guidance from the Interagency Working Group on Technology Transfer.[1] Historical data (i.e., data before FY 2022) for new metrics introduced in the guidance are not available for comparison with FY 2023 data.

[1] The Technology Partnerships Office, National Institute of Standards and Technology, in conjunction with the Interagency Working Group on Technology Transfer, Guidance for Preparing Annual Agency Technology Transfer Reports Under the Technology Transfer Commercialization Act, Published April 2020, Revised September 2022. Available at: https://www.nist.gov/system/files/documents/2022/10/03/2020%20Metrics%20Guidance%20-%20Revised%20September%202022.pdf

III. Technology Transfer in the Department of the Interior

Interior's FY 2023 enacted budget included $1.35 billion for R&D. Most funding, about $1.046 billion, was for applied R&D, while basic R&D and experimental development received about $101 million and $203 million, respectively.[2] The programs supported through these funds generate new and improved knowledge, information, and technology, which are then transferred to resource managers within and beyond the Department, other stakeholders, and the public to help Interior meet its mission objectives.

The Department's bureaus have varying levels of involvement with scientific and technical research, and innovation and technology transfer. In FY 2023, as in previous years, most technology transfer activities reported by the Department under the Federal Technology Transfer Act of 1986 (FTTA) were undertaken by the U.S. Geological Survey (USGS), which is the Department's largest R&D organization, both in terms of budget and personnel. Typically, the USGS accounts for about two-thirds of the Department's R&D budget.

Interior advances the state of knowledge related to the resources it manages and ensures that this information is accessible to resource managers, private industry, and the public. The vast majority of the Department's technology transfer activities use traditional technology transfer mechanisms, such as publications of peer-reviewed papers and reports, webpage postings, fact sheets, and presentations at meetings and conferences.

Bureaus also use other conventional approaches to share scientific and technical resources and expertise with universities and other entities to address resource management issues. For example, eight Interior bureaus and offices are active participants in the Cooperative Ecosystem Studies Units (CESU) Network, a collaboration among 19 Federal agencies and nearly 490 non-federal partners (including universities, Tribes and Tribal organizations, State agencies, museums, aquariums, arboretums, and conservation organizations). The CESU Network extends across biogeographic regions in all 50 States, the District of Columbia, and U.S. insular areas. Each CESU is hosted by a university.[3]

In addition, some bureaus and offices have offered prizes to help develop new or improve existing technologies. The bulk of the prize competition activities at the Department are undertaken by Reclamation's Prize Competitions Program.

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[2] Estimates furnished by the Office of Budget, Department of the Interior.

[3] Cooperative Ecosystem Studies Units National Network: http://www.cesu.psu.edu/materials/default.htm

Bureaus that are active in R&D or have research capabilities that complement U.S. commercial interests may also utilize technology transfer agreements authorized by the FTTA to join forces with non-Federal partners. Such agreements allow the Department's bureaus and the non-governmental sector (including private entities) to pool their expertise and resources to jointly create and advance technologies that support agency missions while helping U.S. industries innovate and commercialize technologies that strengthen the economy and create jobs. This report focuses primarily on, but is not limited to, aspects of technology transfer related to the FTTA.

IV. Overview of Technology Transfer Activities

During FY 2023, the Department continued to engage in a broad range of cooperative activities to develop and disseminate innovative technologies, including:

- Collaborated on 34 CRADAs, of which two were initiated in FY 2023. In addition, the Department engaged in at least 1,669 other collaborative R&D relationships.
- Disclosed 10 new inventions. (No new patent applications were filed, and no new patents were awarded.)
- Managed 74 active patent licenses for inventions and other intellectual property, which collectively earned $76,794.
- Published more than 3400 reports, books, fact sheets, and other publications, disseminating mission-relevant scientific and other technical information to the public and peers in and out of government.

Interior bureaus used 12 mechanisms to transfer information, knowledge, and technology within and outside their agencies (Table 1).

TABLE 1: INTERIOR TECHNOLOGY TRANSFER ACTIVITIES BY BUREAU

	USGS	FWS	OSMRE	NPS	BSEE	BOR	BOEM	BLM
Technical/Scientific Publications	X	X	X	X	X	X	X	X
Workshops/Seminars	X	X	X	X	X	X	X	X
Educational Courses & Other Outreach	X	X	X		X	X	X	X
Cooperative Research and Development Agreements (CRADAs)	X	X		X		X	X	
Technical Assistance Agreements (TAAs)	X							
Facility Use/Service Agreements (FUSAs)	X					X		
Material Transfer Agreements	X			X		X		
Demonstration/Joint Projects	X				X	X	X	X
Patents	X	X		X				
Licenses	X	X				X		
Other Cooperative Ventures & Agreement Types	X	X	X	X	X	X	X	X
Web and Other Mechanisms	X	X	X	X	X	X	X	X

V. Technology Transfer Agreements

In FY 2023, Interior bureaus were involved in 34 active CRADAS and well over a thousand other technology transfer agreements (Table 2).

TABLE 2: COLLABORATIVE RELATIONSHIPS FOR RESEARCH & DEVELOPMENT (FY 2023)

	USGS	BOR	FWS	NPS	BLM	Total
CRADAs						
Total Active CRADAs	26	2	4	2	0	34
New CRADAs	2	0	0	0	0	2
New CRADAs Involving Small Businesses	0	0	0	0	0	0
Other collaborative R&D relationships						
Other Collaborative Agreements, total active in FY 2023	1309	5	0	0	355	1,669

Interior bureaus also disclosed 10 new inventions in FY 2023, most from USGS (Table 3).

TABLE 3: INTERIOR PATENT ACTIVITY (FY 2023)

	USGS	BOR	Total
Invention Disclosures			
Total Invention Disclosures Received	9	1	10
Patents			
Total Patent Applications Filed	0	0	0
US	0	0	0
Foreign	0	0	0
Total PCT Applications Filed **(NOTE: PCT = Patent Cooperation Treaty. See https://www.wipo.int/pct/en/)**	0	0	0
Total Patents Issued	0	0	0
US	0	0	0
Foreign	0	0	0

Interior managed 74 invention licenses in FY 2023. Table 4 presents data on active licenses and the time required to grant them.

TABLE 4: ACTIVE LICENSES MANAGED BY INTERIOR BUREAUS (FY 2023)

	USGS	FWS	Total
Invention Licenses, Total Active	73	1	74
New Invention Licenses	2	0	2
New Invention Licenses to Small Businesses	2	0	2
Income bearing licenses, Total Active	12	1	13
New Income Bearing Licenses	0	0	0
Exclusive licenses	9	1	10
Partially exclusive licenses	0	0	0
Non-exclusive licenses	3	0	3
Other Licenses, Total Active	61	0	61
New Other Licenses	6	0	6
New Other Licenses Granted to Small Businesses	0	0	0
Average (months)	2.5	0	2.5
Minimum (months)	2	0	2
Maximum (months)	3	0	3
Licenses terminated for cause	0	0	0

Total income in FY 2023 from all licenses amounted to $76,794 (from 12 income-bearing licenses), compared with $108,761 (from 10 income-bearing licenses) in the previous fiscal year. Under 15 USC § 3710c, for all inventions originating in a Federal agency, the agency must pay to the employee-inventors the first $2,000 per year in license income, and a minimum of 15% of the yearly income thereafter. Each agency has discretion to implement its own sharing scheme, but the maximum that a single inventor can receive per year is $150,000. Any residual funds are usually retained by the agency or laboratory where the intellectual property was developed.[4]

The scope and nature of Interior bureaus' technology transfer activities reflects their missions. See Table 5.

[4] https://www.govinfo.gov/content/pkg/USCODE-2011-title15/html/USCODE-2011-title15-chap63-sec3710c.htm

TABLE 5: SCOPE OF ACTIVITIES AND PLANS RELATED TO THE FTTA, BY BUREAU

Mission	Technology Transfer
U.S. Geological Survey (USGS). The mission of the USGS is to serve the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.	The USGS serves the Nation as an independent fact-finding agency that collects, monitors, and analyzes scientific and technical information to provide scientific understanding about natural resource conditions, issues, and problems. The USGS makes this information and knowledge readily available to decision makers and the public. Thus, one of the USGS's main thrusts is broad and open dissemination of its knowledge and information. The USGS also pursues technology transfer opportunities under the FTTA and the Stevenson-Wydler Act in a variety of ways.
U.S. Fish & Wildlife Service (FWS). The mission of FWS is working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.	FWS's R&D is primarily focused on providing the basis for effective conservation to meet its mission. For example, the FWS Fish Technology Centers (FTCs) were established in 1965 to develop and improve fish culture technology and to assist Federal and State agencies, Tribes, and other nations interested in aquaculture research and solutions. FTCs have worked with industry and government to improve aquaculture opportunities.
Office of Surface Mining Reclamation and Enforcement (OSMRE). OSMRE is responsible for ensuring, through a nationwide regulatory program, that coal mining is conducted in a manner that protects communities and the environment, restores the land to beneficial use following mining, and mitigates the effects of past mining by aggressively pursuing reclamation of abandoned mine lands.	OSMRE advances its mission by providing technical assistance, based on sound science and training, to its State and Tribal partners to enhance their ability to maintain effective programs. Although OSMRE has no formal R&D activities, its Technology Development and Transfer program promotes and disseminates information on technological innovations to better protect the environment during mining and in reclaiming and restoring active and abandoned mines. The program also provides training to ensure that States, Tribes, and OSMRE's other partners continue to administer their surface mining programs efficiently and effectively.
National Park Service (NPS). The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of current and future generations. NPS cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.	Technology transfer and employee inventions are addressed under the NPS benefits-sharing policy and procedural guidance. Benefits sharing occurs when NPS receives monetary or nonmonetary benefits from the commercial use of a discovery or invention resulting from research originating under an NPS Scientific Research and Collecting Permit or other NPS permit or authorization. Authorities under the FTTA are essential to the NPS benefits-sharing program.

Mission	Technology Transfer
Bureau of Safety and Environmental Enforcement (BSEE). BSEE works to promote safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement.	The BSEE R&D program activities operate through the Office of Offshore Regulatory Programs, Emerging Technologies Branch, and the Oil Spill Preparedness Division, Oil Spill Response Research role. BSEE research is associated with operational safety, pollution prevention, and oil spill cleanup techniques and technologies. BSEE research results are used to inform regulatory decision-making and promote Best Available and Safest Technology on the U.S. Outer Continental Shelf.
Bureau of Reclamation (Reclamation or BOR). The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.	Reclamation has the lead Federal responsibility for water management and hydropower in the 17 western States. Its research program is applied toward the development of solutions that increase efficiency, reduce maintenance costs, improve work safety, enhance infrastructure reliability, and increase the effectiveness of using desalination and other water treatment technologies to expand water supplies. The research programs use technology transfer fundamentals to help speed field deployment of new innovations.
Bureau of Ocean Energy Management (BOEM). BOEM manages the exploration and development of the Nation's offshore energy and mineral resources in an environmentally and economically responsible way. It seeks to appropriately balance economic development, energy independence, and environmental protection through oil and gas leases, renewable energy development, and environmental reviews and studies.	BOEM's Environmental Studies Program develops, conducts, and oversees scientific research specifically to inform policy decisions regarding development of OCS energy and mineral resources. The research covers physical oceanography, atmospheric sciences, biology, protected species, social sciences, economics, submerged cultural resources, and environmental fates and effects. BOEM also funds research into offshore renewable energy technologies.
Bureau of Land Management (BLM). The BLM mission is to sustain the health, diversity, and productivity of America's public lands for the use and enjoyment of present and future generations. The Federal Land Policy and Management Act of 1976 (FLPMA) mandates that BLM manage public land resources for a combination of balanced and diverse resource uses that take into account the long-term needs of future generations for renewable and nonrenewable resources, including, but not limited to, recreation, range, timber, minerals, watershed, wildlife and fish, and natural scenic, scientific, and historical values.	BLM's scientific and technical focus has been on place-based applications to improve public land management in accordance with FLPMA. BLM focuses on traditional technology transfer activities to help advance FLPMA's multiple-use mandate.

Subsequent sections briefly describe each bureau's technology transfer program and provide examples of their activities in FY 2023. The tabular data requested by Office of Management and Budget Circular A-11 are reported in section XVI, "Data Appendix."

VI. U.S. Geological Survey

The USGS is a science bureau within Interior whose mission is to serve the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. The USGS focuses on the following interdisciplinary mission areas: Core Science Systems; Ecosystems; Energy and Mineral Resources; Natural Hazards; and Water Resources. The combined expertise from several earth-science disciplines (such as hydrology, geology, and biology) addresses relevant issues of concern to people and other living things on the planet. Organization around these mission areas allows the USGS to better address the needs of the Nation, customers, and partners.

Delivery of scientific information is the USGS's primary mission. Technology transfer activities with the public and private sectors, including academia and nonprofits, are integral to fulfilling this mission. These efforts typically support knowledge dissemination, including the collection and transfer of scientific data. The USGS also cooperates with its public and private collaborators to help them maintain essential and necessary services, better understand the environmental consequences of their commercial and noncommercial activities, and develop new products and services. The USGS has over 280 laboratories across the country.

Within the USGS, technology transfer extends beyond traditional publications, meetings, and conferences. It builds on the Stevenson-Wydler Innovation Act of 1980, as amended by the FTTA and the National Technology Transfer and Advancement Act of 1995, and is managed through the USGS Office of Policy and Analysis (OPA). OPA serves USGS centers and offices throughout the country.

OPA negotiates and drafts CRADAs and other types of collaborative agreements, including technical assistance agreements, facility use service agreements, material transfer agreements, data use licenses, and patent licenses. OPA also manages the USGS intellectual property and inventions program; markets USGS technology opportunities; and facilitates partnerships with industry, nonprofits, academic institutions, Federally recognized Tribes, and State agencies. OPA also provides training to USGS personnel on technology transfer and intellectual property matters.

In fiscal year 2023, the USGS had 26 active CRADAs, two of which were new. In addition to those CRADAs, the USGS executed 1,309 collaborative agreements. Of these agreements, 937 were joint funding agreements for topographical mapping or water resources investigations. The remaining agreements include 108 technical assistance agreements, 173 collaborative agreements, and 91 facility use and service agreements.

The USGS published a total of 3,049 scholarly articles, papers, and book chapters focused on diverse areas (such as matters about understanding the Earth; minimizing loss of life and

property from natural disasters; and managing water, biological, energy, and mineral resources). The USGS also managed a total of 73 active intellectual property licenses.

Notably, USGS's patented method of creating "Safe, directional, drought-resistant dug well," U.S. Patent, 9,689,235 was licensed in 2023. This invention helps to reduce well drought and arsenic in drinking water, which is a growing concern in parts of the United States. The license allows a commercial entity to install the wells, expanding public access to this USGS patented technology. This may improve public health by ensuring the availability of safe drinking water. It also leads to a reduction in long-term exposure to high levels of inorganic arsenic in drinking water that has been associated with certain medical conditions, including skin disorders, an increased risk for diabetes, high blood pressure and several types of cancer.

USGS science and research contributes to a broad range of collaborative projects in the private and academic sectors. Examples include the following:

U.S. Wind Turbine Database. The USGS, led by Research Ecologist Jay Diffendorfer, formed a research project with Lawrence Berkeley National Laboratory (LBNL), and the American Wind Energy Association (AWEA, the predecessor of American Clean Power Association, ACP). The project began in 2016, under a CRADA to develop a U.S. Wind Turbine Database (USWTDB). Funding was supported from the U.S. Department of Energy (DOE), LBNL, and the ACP. Data for the USWTDB was generated combining publicly available data sets from the Federal Aviation Administration (FAA), an earlier USGS wind turbine dataset, online sources, and those privately held by ACP and LBNL.

Wind facility studies are critical to developing U.S. natural energy resources to provide clean energy and to generate U.S. economic growth. The USWTDB is the most current, accurate, and publicly available renewable energy dataset in the world. This dataset was released to the public via an online portal[5] in April 2018 and made available as a downloadable database. As such, it can be used to create and customize independent models for research based on the available data. In 2023, the site received 3,990,901 total visits.

[5] Accessible at https://eerscmap.usgs.gov/uswtdb/.

A FIELD OF WIND TURBINES IN WYOMING WITH A STORM ROLLING IN. PHOTO: PAUL CRYAN, USGS

The USWTDB provides the locations of land-based and offshore wind turbines in the United States, corresponding wind project information, and turbine technical specifications. The database, with over 17 million visits since 2018, includes 74,511 turbines. It reflects exponential growth of wind energy and new wind facilities. Dataset users include U.S. military, Federal and State governments, academic institutions, foreign nations, and the public. The overall impact of the USWTDB is potentially immense and multifaceted as this data can lead to development of new markets and jobs. It also can aid the development of low cost-renewable energy sources, access to energy in remote locations and increase energy and related revenue.

A SUBSET OF THE WIND TURBINE LOCATIONS IN THE CONTIGUOUS UNITED STATES SHOWN IN THE U.S. WIND TURBINE DATABASE (USWTDB) VIEWER. SOURCE: USGS

For example, Federal and State permitting entities continuously use this data when considering new wind energy and its cumulative impacts in considering permits for new wind facilities. Additionally, academics around the world use this database for studies on wind turbine physics, improved wind plant efficiencies and operations, social acceptance, economics, land cover change, wildlife impacts, micrometeorology, wind energy life cycle and waste stream assessments.

Ecological Impacts of 6PPD-Q. In FY 2023, the USGS and the U.S. Tire Manufacturers Association (USTMA) assessed the ecological impacts of the chemical compound known as "6PPD" (N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine) and evaluated methods to find an alternative to that compound. 6PPD is present in all tires on U.S. roads. It is used to prevent tires from breaking down due to reactions with ozone and other reactive oxygen, slowing the tire degradation rate. However, when 6PPD reacts with ozone, it changes into 6PPD-quinone ("6PPD-Q"), which is an environmental toxin.

THE CHEMICAL COMPOUND KNOWN AS 6PPD IS PRESENT IN ALL TIRES ON U.S. ROADS, BUT EXPOSURE TO OZONE CONVERTS IT INTO A TOXIC SUBSTANCE THAT HARMS AQUATIC SPECIES SUCH AS SALMON. USGS IS WORKING TO FIND AN ALTERNATIVE TO 6PPD.PHOTOS: MICROSOFT STOCK IMAGES (TOP ROW), BLM (BOTTOM)

As tires wear down, particles enter waterways (e.g., through storm runoff on roadways). Exposure to 6PPD-Q negatively impacts salmon, trout, and other aquatic species' survivability

rate and development. This is of significant concern to American Indian Tribes, States, scientists, and the public.

Scientists at the USGS Western Fisheries Research Center are advancing the use of animal cell lines for testing the impacts of 6PPD-Q and exploring alternative chemicals for tire protection. This is also being done in partnership with the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology to evaluate potential alternatives using new investigative methods.

This research can have nationwide impact by reducing the use of a toxin that negatively affects the lifespan and development of aquatic species. This can lead to a safer alternative for the environment while still support long-lasting tires and safe driving.

VII. U.S. Fish and Wildlife Service

The FWS is dedicated to the conservation, protection, and enhancement of fish, wildlife, and plants and their habitats. FWS is the only Federal agency whose primary responsibility is managing fish and wildlife resources for the American public. The National Wildlife Refuge System's 855 million acres of lands and waters includes 571 national wildlife refuges, waterfowl production areas in 209 counties managed within 38 Wetland Management Districts and 49 Coordination Areas, and five National Monuments, including more than 759 million cooperatively managed acres of submerged lands and waters. FWS also operates National Fish Hatcheries, which, in conjunction with Fish and Wildlife Conservation Offices, its Fish Health Centers and Fish Technology Centers, restore native aquatic populations, mitigate fish losses caused by Federal water projects, and support recreational fisheries throughout the United States.

R&D within FWS is primarily focused on applying the latest scientific and technical information to fulfill its mission. Transferring FWS's technology and knowledge to the public and collaborators accelerates the adoption and use of agency research while improving the economic and societal benefit from its R&D investments to help solve natural resource problems.

The technology transfer function of FWS is shared among several programs, including Science Applications, Fish and Aquatic Conservation (FAC), and Joint Administrative Operations (JAO). The majority of FWS's technology transfer is done via dissemination to the public and scientific community through traditional avenues such as peer-reviewed papers, presentations, reports, and fact sheets. Science Applications and JAO help coordinate technology transfer activities in the Service while other programs are more directly involved with partners.

FWS employees are actively involved in the larger scientific community and participate in scientific societies, meetings, and conferences and publish scientific research. Sharing scientific and technical information via public outreach and partnerships is a high priority for FWS. For example, FWS is a partner to all units within the 17 CESU Network, allowing FWS to be involved in interdisciplinary and multiagency research projects with the host university and other non-Federal partners. Each year, FWS pursues dozens of projects through the CESU network, including surveying and monitoring efforts, climate change vulnerability assessments, streamflow projections, and many others.

Scientists within the agency published 473 scholarly articles, papers, or book chapters in publications focused on diverse topics such as ecology, biodiversity conservation, fisheries, zoology, ornithology, environmental sciences, and evolutionary biology. FWS also manages two

online peer-reviewed publications focused on the practical application and integration of applied science to wildlife conservation and management—the *Journal of Fish and Wildlife Management* and the *North American Fauna Monograph Series*. These electronic journals are in the public domain. FWS also uses its research to help inform a wide range of wildlife management decisions in the interest of the general public. For example, the National Wildlife Refuge Inventory and Monitoring Program systematically obtains a range of biological data about the status, trends, and management responses of species and habitats within the National Wildlife Refuge System.

While the scope of FWS technology transfer activities is relatively small, FWS carried out several new and ongoing technology transfer activities in FY 2023:

Aquatic Animal Drug Approval Partnership Program (AADAP). In FY 2023, FWS maintained four CRADAs through the AADAP within its FAC Program. These CRADAs were created with pharmaceutical companies in collaboration to work towards drug approvals for use in aquaculture and fisheries management. On behalf of the Department, FWS also maintains a joint CRADA involving the USGS and BOEM and Bird Studies Canada.[6]

National Conservation Training Center. The FWS Conservation Library[7] at the National Conservation Training Center (NCTC) in Shepherdstown, West Virginia, provides a searchable collection of selected documents, images, historical artifacts, audio clips, publications, and videos, most of which are in the public domain. FWS also makes internal publications, reports, and other information available to the public through the FWS website.[8] Collections of current and legacy publications (including biological and technical publications) are available online from the NCTC library catalog and websites. NCTC also maintains links to biological and technical publications, as well as additional publications regarding birds, wetlands, fish hatcheries, and National Wildlife Refuges. The FWS Conservation Library provides streamlined access to scientific information to FWS professionals and partners, with over 120,000 searches performed in FY23.

NCTC hosts publicly accessible webinars dealing with a variety of scientific and technical issues that address the nation's fish and wildlife resources. During fiscal year 2023, NCTC hosted 94 in-person classes, 16 online science, technology, and educational webinars and 62 e-courses related to managing the Nation's fish, wildlife, and plant resources. These are important

[6] Because the FWS/USGS/BOEM/Bird Studies CRADA is already accounted for in the USGS tally of CRADAs, it is not included in the tallies for the other bureaus in Section V and the data tables in the Appendix.

[7] URL: http://digitalmedia.fws.gov.

[8] URL: https://www.fws.gov.

components of FWS's traditional technology transfer activities that resulted in expanded partnerships and professionals achieving FWS, Interior, and Administration conservation priorities.

While they reported no specific accomplishments in FY23, the following FWS programs also relate to technology transfer:

Fish Technology Centers. Starting in 1965, Fish Technology Centers (FTCs) were established to develop and improve fish culture technology and to provide assistance and advice on fish culture to National Fish Hatcheries, other federal and state agencies, tribes, other nations, and the aquaculture industry. The FTCs have developed culture techniques to support recreational fisheries, restoration of aquatic species at risk and for threatened and endangered species that require captive propagation and rearing for their recovery.

Nutrition and Diet Development Laboratories. These facilities allow for the manufacture of experimental fish diets now used around the world. These labs have developed fish feeds for larval, fingerling, and broodstock fish, including dehydrated long-lasting feeds that revolutionized the fish-culture industry and specialized diets for use in captive rearing of endangered fish species.

Conservation Genetics Laboratories. These laboratories support conservation and management needs of FWS and its partners using genetic methods to identify species and strains, assist with Endangered Species Act implementation, maintain genetic tissue and repositories for imperiled species, and monitor invasive and native species using environmental DNA (eDNA). Genetic management allows us to make management decisions to support the long-term viability of healthy populations of fishes and other aquatic species in our waters.

Physiological Ecology Laboratories. These laboratories support conservation and management needs by understanding the physiological requirements and tolerances of threatened and endangered species. They use less- or non-invasive tools such as measurement of plasma sex steroids and ultrasound, as well as blood chemistry analysis, histology, proximate analysis, and radio-immunoassays. Together, these tools support conservation and commercial opportunities through management of reproductively robust populations in captivity and in the wild.

Fish Health Centers. Fish Health Centers work closely with federal, state, tribal, academic, and non-governmental organization partners to promote the scientific management of fisheries and aquaculture by reducing the effects of wildlife pathogens. They play a vital role in ensuring that the nations aquatic animals are healthy and able to be translocated internationally and domestically to both aquaculture industry and national resource stakeholders.

Aquatic Invasive Species. The FWS Aquatic Invasive Species program works to prevent the transfer and introduction of injurious and other potentially harmful non-native species and to support development and implementation of prevention early detection and rapid response (EDRR), and control measures for such species. The program helped to establish a network of to collect and process eDNA samples from federal, state, and tribal partners across the country.

VIII. Office of Surface Mining Reclamation and Enforcement

The OSMRE, established by the Surface Mining Control and Reclamation Act of 1977 (SMCRA), is responsible for ensuring that coal mining is conducted in a manner that protects communities and the environment and restores the land to beneficial use following mining, and mitigating the effects of past mining by aggressively pursuing reclamation of abandoned mine lands (AML). OSMRE achieves this in part by providing technical assistance and technology transfer activities to its State and Tribal partners to enhance their ability to maintain effective programs.

The goals that underlie OSMRE's Technology Development and Transfer program include: (a) increasing the technical knowledge of the reclamation of active and abandoned coal mines; (b) developing and enhancing working relationships among the bureau's partners in Federal, State, and Tribal governments and in industry and academia; and (c) leveraging its resources through partnerships. These combined lines of effort provide better informed decision-making and more enduring remediation of hazards and environmental degradations for our programmatic partners and ultimately the public. OSMRE accomplishes these goals via the Technical Innovation and Professional Services (TIPS) program, the National Technical Training Program (NTTP), and the National Technology Transfer Team (NTTT).

Technical Innovation and Professional Services. TIPS is a national program that researches and applies emerging technologies to SMCRA workflows. TIPS provides State, Tribal, and OSMRE personnel with a comprehensive set of analytical tools to aid in technical decision-making related to regulatory and reclamation processes. The services provided are centered on off-the-shelf scientific and engineering computer software and technical hardware supported by OSMRE in partnership with the States and Tribes. The TIPS suite of scientific, hydrologic, and mapping core software aids the technical decision-making associated with a wide variety of tasks that surface mining agencies must perform regularly.

Currently, TIPS assistance includes providing commercial software applications and hardware to State, Tribal, and OSMRE offices at considerable cost savings by sharing the commercial licenses for 20 commercially available software applications via the Internet and an OSMRE-wide area network. The customer base covers more than 60 State, Tribal, and OSMRE office locations throughout the country.

Demand for TIPS tools and support continues to increase, especially for geospatial data and mobile computing tools for field use. TIPS is offering more onsite training for State, Tribal, and Federal personnel to familiarize them with use of mobile computing devices by inspectors. The TIPS Training Program is a collaborative effort among OSMRE, States, and Tribes. Course developers and instructors are reclamation experts who use TIPS software to solve a wide

range of complex permitting, enforcement, and AML problems. Although most TIPS tools are off-the-shelf applications, TIPS training is tailored exclusively to mining and reclamation uses. TIPS courses are delivered at OSMRE's Regional Offices in Alton, Illinois; Pittsburgh, Pennsylvania; in rental training facilities at various locations; and on site at the customer's request. When trained, the students are able to use the technical resources to solve complex SMCRA permitting, enforcement, and AML-related matters to protect the public and the environment.

In FY 2023, the TIPS training program received a customer satisfaction rating of 100 percent, exceeding the annual Government Performance and Results Act goal of 96 percent. TIPS had not fully re-established in-person classes as transitioning out of the COVID-19 pandemic continues; therefore, 31 virtual vendor-instructed classes were scheduled. TIPS held 52 virtual classes and taught one in-person special training session request in Kentucky. For FY 2023, there were 302 students trained, which was a 238% increase from FY 2022.

Mobile computing increases efficiency in resolving State, Tribal, and industry issues. Below are additional details on the computing and mapping tools the TIPS program supports. Deployment of the TIPS technical solutions result in better-informed decision-making and resource management, ultimately maximizing the value of public investments in technology and ensuring that taxpayer dollars are used effectively.

GeoMine Web Application. GeoMine provides authoritative data for surface coal mining operations across the country, merging data from numerous sources to create standardized, seamless layers that cross State and Tribal Nation boundaries. It continues to support a diverse user base by providing several standardized, interoperable coal mining-related geospatial datasets, as well as high-resolution aerial imagery. Users include individuals, non-governmental organizations like Trout Unlimited and Appalachian Voices, educational institutions including the University of Washington, and other Interior bureaus.

Users can access GeoMine to quickly find answers to basic questions about coal mines, such as their proximity to family, property, or schools. Although many States also provide this data publicly, GeoMine offers a centralized repository for easy access. Its continued use increased last year to 2,300 searches and over 160 downloads.

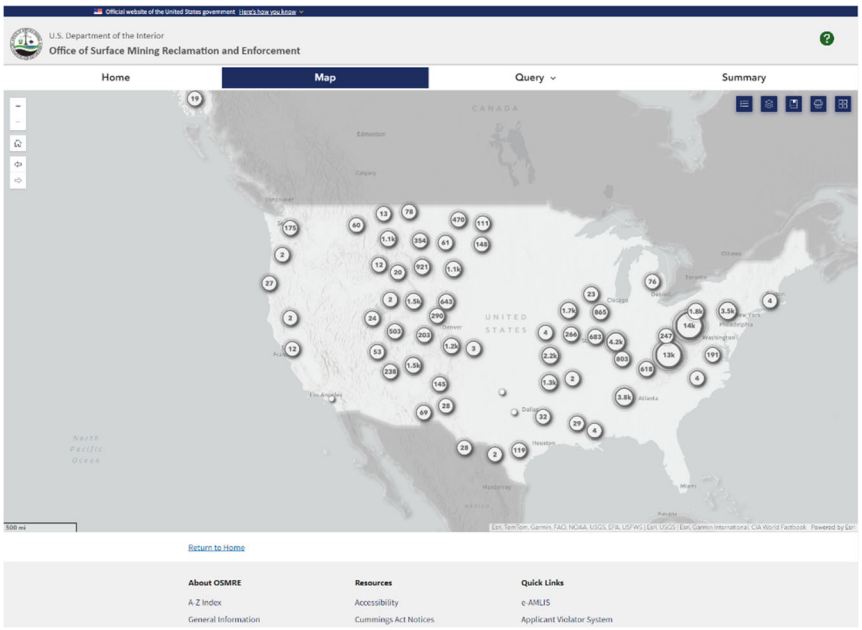
GIS Mobile Applications. In FY 2023, OSMRE continued the use of tablets and smartphones that can display and collect geospatial data while at mine or AML site investigations. OSMRE uses these devices to train Tribal and State SMCRA partners in the field. Several of the OSMRE-supported mobile applications are listed below:

- Esri Survey123
- Esri Field Maps
- Avenza Maps
- Global Mapper Mobile

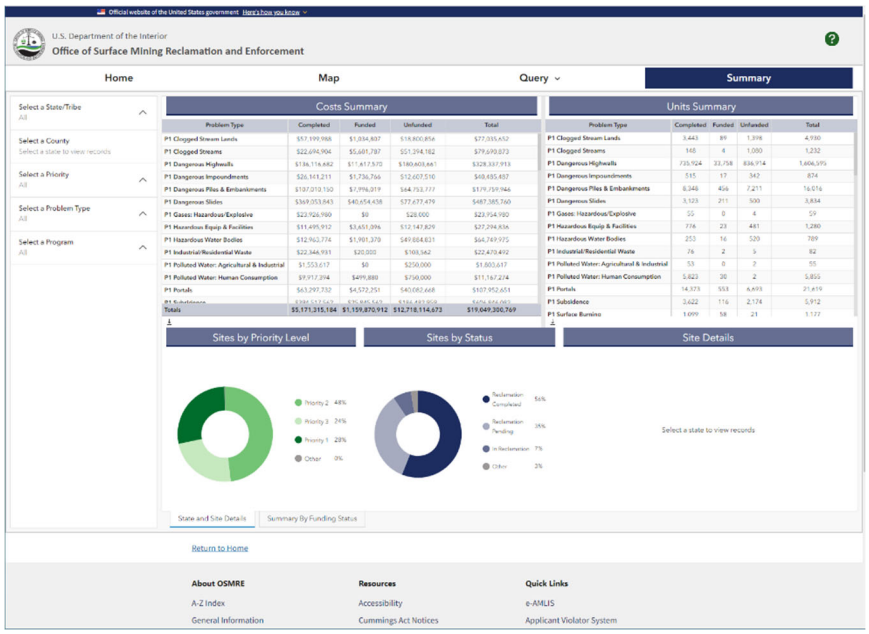
Survey123 and Field Maps, the primary mobile apps for field use, easily leverage enterprise level datasets hosted in ArcGIS Online. Avenza and Global Mapper Mobile lend themselves to situations where enterprise data collection is not a priority. Several State programs take advantage of these applications, as do individuals who need to see a map in the field or who only need to store the data they collect on their own device.

ArcGIS Online. The ArcGIS Online web mapping system allows access to OSMRE and shared geospatial data. When mine inspectors conduct field work, this system allows them to collaborate with SMCRA partners, such as inspectors, office staff, and managers, in near-real time, boosting efficiency across all workflow stages. In FY 2023, the system had over 600 State and Tribal members and more than 800 total active users, with an increase of over 300 users between FY 2022 and FY 2023. ArcGIS Online also serves as the primary licensing mechanism for the Esri desktop application ArcPro. States and Tribes make frequent use of ArcPro to aid day-to-day workflows on inactive or abandoned mines.

E-AMLIS Public Mapping Viewer. With Esri support, OSMRE has modernized the public mapping component of the e-AMLIS system. Combining maps, dashboards, charts, and widgets, the new mapping system offers an updated user experience with more powerful search, filter, and map visualization capabilities. Users can map Problem Area Description data against other datasets like census and Justice40 tracts, as well as review cost summaries by feature type, location, and more. Basic and advanced query capabilities provide the ability to investigate the nationwide dataset using a combination of many different attributes to extract valuable insight into reclamation progress across the country. Additional upgrades to the reporting capabilities are planned for the near future.



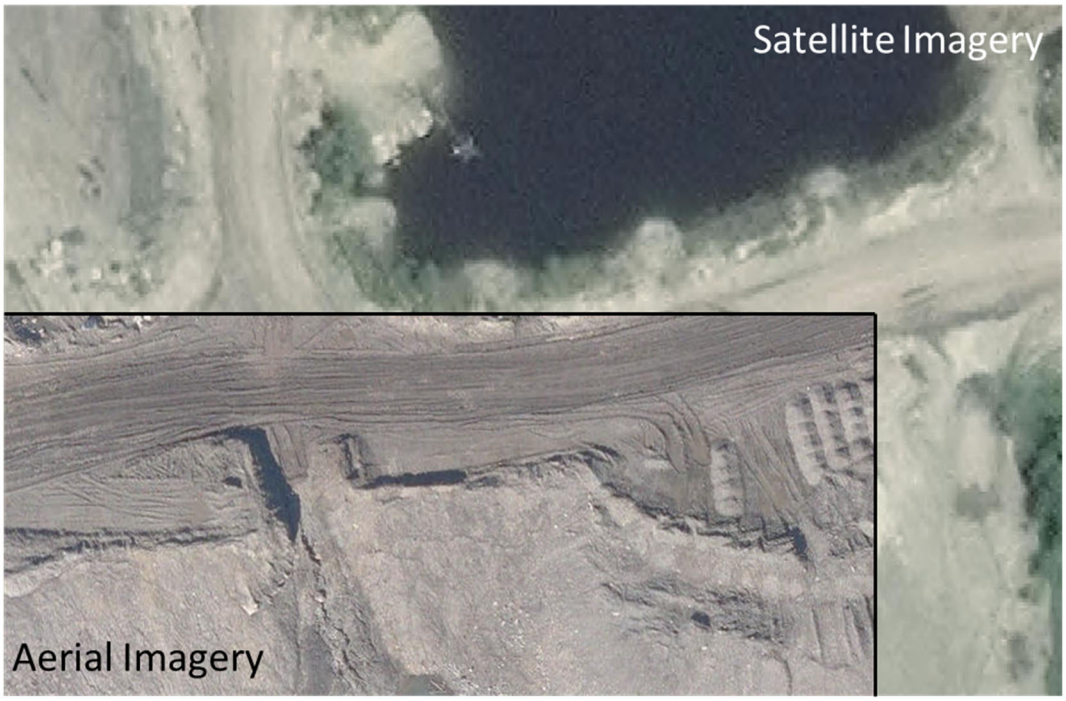
E-AMLIS NEW PUBLIC WEB VIEWER - MAP. SOURCE: OSMRE



E-AMLIS NEW PUBLIC WEB VIEWER – SUMMARY DASHBOARD. SOURCE: OSMRE

Remote Sensing Direct Program Support. Remote sensing data allows OSMRE and its partners to monitor mining and reclamation, ensuring that former mined lands are safely and thoroughly restored. In FY 2023, OSMRE was able to collect high-resolution aerial topography and imagery to aid inspectors and Title IV and Title V SMCRA partners in Interior Regions 5 and 7-11. OSMRE will not be able to collect this data in FY24 due to

reductions in OSMRE's FY24 appropriations. OSMRE must now rely on lower resolution data (satellite imagery) that will result in inspectors missing small issues at former mined lands and less accurate volumetric calculations.



SATELLITE IMAGERY (TOP); AERIAL IMAGERY (BOTTOM) OF AN ACTIVE SURFACE COAL MINE. SOURCE: OSMRE.

Leading the remote sensing effort is OSMRE's senior remote sensing expert. This position is responsible for remote sensing analysis, education, training, and exploring new techniques crucial to advancing OSMRE's ability to administer SMCRA responsibilities through remote sensing. In FY 2023, the senior remote sensing expert used aerial imagery with an algorithm (validated by field calculations) to measure iron concentrations and soil moisture at a mine site in the State of Washington. Too much or too little iron can significantly hamper reclamation through poor vegetation health.

National Technical Training Program. Established in 1985, the NTTP enhances the technical skills and professionalism of State, Tribal, and OSMRE regulatory and reclamation staff. NTTP keeps participants up to date with the latest technologies, methodologies, and policies to ensure best practices in protection and land restoration. The program, a collaborative effort among State, Tribal, and OSMRE offices, offers comprehensive training aligned with SMCRA mandates.

In FY 2023, 87 instructors and subject matter experts from State, Tribal, and OSMRE offices provided support for curriculum delivery and curriculum development for 42 courses, one

special session, and seven course revisions. These experts specialize in mining regulatory and reclamation practices. NTTP's training portfolio also includes 12 online self-paced courses, which complement in-person offerings.

Following enactment of the 2021 Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Law (BIL), NTTP developed the Introduction to SMCRA and BIL curriculum. This training, revised in 2023, is available online through DOI Talent, covering updates to SMCRA, NEPA, e-AMLIS, and Reclamation Planning. In FY 2023, 149 students completed this curriculum.

NTTP courses cover diverse technical areas such as AML restoration, inspection techniques, soils and revegetation, handling toxic materials, water-quality assessments, legal enforcement procedures, and preparation of evidence and testimony. In FY 2023, there were 615 in-person and 1,119 online course completions, achieving a 97% course effectiveness rating based on student feedback.

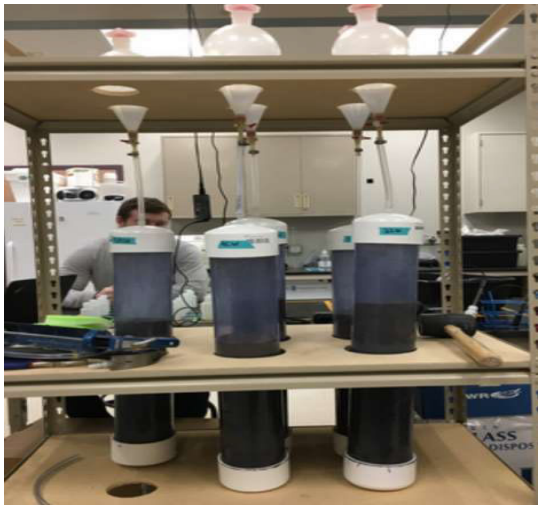
The training provided by NTTP ensures that the individuals responsible for regulating and overseeing mining activities are well-equipped with the latest knowledge and techniques. This helps prevent environmental damage, ensures safe land restoration, and promotes the responsible use and protection of natural resources.

BLASTING AND INSPECTION TRAINING COURSE, LEXINGTON, KY 2024. SOURCE: OSMRE

National Technology Transfer Team (NTTT). The NTTT team brings together members of OSMRE, State and Tribal SMCRA programs, and representatives from the Interstate Mining Compact Commission and the National Association of Abandoned Mine Land Programs (NAAMLP), to coordinate understanding of mining-related issues across the country.

The NTTT collaborations result in exchanges of latest technologies in various mine-related aspects such as mine drainage treatment processes, UAS (uncrewed aerial services), and reclamation best management practices that result in increased efficiencies and cost savings to State and Tribal partners. NTTT programs include the following:

Applied Sciences Program (ASP). NTTT manages and promotes the ASP with the goal to develop, demonstrate, and share improved technologies to address environmental issues related to the mining of coal and subsequent reclamation of the land. The program accomplishes this by funding studies conducted by universities, nonprofit organizations, and SMCRA regulatory authorities covering topics such as coal mine reclamation, revegetation, blasting, hydrology, coal mine voids and fires, soil productivity, acid mine drainage, rare earth elements, and other topics relevant to environmentally responsible mining and reclamation. These projects go beyond theoretical research and investigate application of existing theory to on-the-ground mining and reclamation issues.



CONSTRUCTED AND FILLED LEACH COLUMNS FOR APPLIED SCIENCE BENCHTOP EXPERIMENTS. SOURCE: KRISTEN BROWN, OSMRE

In FY 2023, the ASP team managed eight projects that were selected in FY 2021 and another eight projects that were selected in FY 2023 through a Notice of Funding Opportunity (NOFO) issuance for approximately $1.6 million. The proposals were evaluated based on scientific and technical merit. The projects have a two-year term,

but a no-cost extension can be granted if warranted. Reports and findings of completed projects are available on the OSMRE Applied Science website.[9]

NTTT continued to manage the interactive Applied Science GIS application that allows any interested party to access quarterly status reports for funded and ongoing projects. The GIS application can be accessed on the ArcGIS dashboard for OSMRE Applied Science.[10]

Mine Drainage Technology Initiative (MDTI). Another program that OSMRE uses to award cooperative agreements is the MDTI, which builds consensus among industry, Federal, and State regulatory agencies on acidic and toxic drainage technology development and technology transfer issues. MDTI cooperative agreements are established under authorities other than the Federal Technology Transfer Act. In FY 2023, OSMRE had two MDTI cooperative agreements funding studies with universities that were in various stages of completion. Also in FY 2023, OSMRE issued another NOFO for an MDTI cooperative agreement, receiving five proposals in response. Like the APS, MDTI cooperative agreements have a two-year term that can be extended at no cost, if justified.

Regional Technology Transfer Events and Activities. NTTT also hosts and participates in technology transfer activities such as workshops, forums, and symposia to collaborate with partners outside the SMCRA community. Some of the nationally recognized conferences offered in-person attendance in FY 2023. NTTT participated and provided promotional displays at the American Society of Reclamation Sciences (ASRS) annual conference and the NAAMLP annual conference.

[9] URL: https://www.osmre.gov/programs/applied-science

[10] URL: https://experience.arcgis.com/experience/ff3243e737cc476da6ab1368f4836b9c

OSMRE BOOTH DISPLAY AT THE AMERICAN SOCIETY OF RECLAMATION SCIENCES ANNUAL CONFERENCE. SOURCE: OSMRE

The Geospatial Services Branch (GSB) within Regions 1 and 2 (AR) represented OSMRE at the 2023 National Historically Black Colleges and Universities Conference. OSMRE showcased the National Mine Map Repository (NMMR), UAS, and a 3D printer, while discussing the history of a coal mine in Wake Forest, Virginia, and how mapping has evolved over time.

The GSB also supported the Pennsylvania of Department of Environmental Protection by piloting UAS missions in support of reclamation and mining features. Specifically, OSMRE provided detailed reports which calculated volumes of refuse piles to determine reclamation costs.

The NMMR team represented OSMRE at three conferences (the American Exploration & Mining Association Conference, Society for Mining, Metallurgy & Exploration Conference, and the NAAMLP Annual Conference) in FY 2023 to promote the map repository and spread awareness of OSMRE services to State partners, the public, and industry. The NMMR maintains over 100,000 abandoned and closed underground mine maps. These maps are crucial for many applications. The NMMR assists both the private and public sectors in evaluation of related data for economic valuation, risk assessment, industrial and commercial development, highway construction, resulting in enhanced preservation of public health, safety, and welfare.

The Geospatial & Technology Transfer Branch within Regions 3, 4, and 6 (Mid-Continent Region; MCR) conducted three Technology Transfer Roadshows during FY 2023 in Indiana, Illinois, and Kansas. The goal of the roadshows is to strengthen relationships between MCR and the mid-continent States technical staff. At the roadshows, OSMRE presents existing and new technology accessible to the mid-continent States through

OSMRE. States can request on-site demonstrations and training during roadshow or schedule them for the future. MCR States can develop their own skills by borrowing OSMRE equipment, or if needed, they can rely on OSMRE technical staff to perform tasks. These engagements result in technical assistance and informed decisions regarding technology acquisition.

IX. National Park Service

As part of its mission, the National Park Service (NPS) actively manages the natural, cultural, and historical resources entrusted to it. This management includes preserving and maintaining these resources and, where necessary, preventing impairment, mitigating adverse impacts, or restoring these resources. Most of these activities are undertaken at the level of each individual park unit, but service-wide networks, programs, and centers make related scientific contributions in areas such as inventory and monitoring and preservation technology.

Scientific activities within NPS focus on improving the understanding and management of park natural and cultural resources. In cooperation with partners, NPS also works to preserve and interpret similar resources outside parks. The information generated by these activities is shared with park managers and stakeholders—including public and private land managers, as well as the broader public—largely through interpretive programs, exhibits, conferences, meetings, training, and standard publication media, such as reports, newspapers, journals, magazines, fact sheets, and webpage postings.

To expand the range of expertise and tools available to it, NPS participates in many collaborative ventures with universities and other governmental and nongovernmental organizations, including the Cooperative Ecosystem Studies Units Network.

NPS Cultural Programs include the National Center for Preservation Technology and Training (NCPTT), which Congress created to fill a fundamental need for research and technology transfer among Federal, State, local, and Tribal governments, Native Hawaiian organizations, educational institutions and other public entities with historic preservation programs. The NCPTT serves as a research and development laboratory for historic preservation and advances the application of science and technology to preservation issues. The NCPTT also supports applied research, partners with professional and scientific organizations, publishes technical guidance for preservation professionals, and trains students and practitioners in the latest preservation techniques.

NPS encourages qualified scientists to undertake research on parks' physical, biological, and other resources under the aegis of park Scientific Research and Collecting Permits and other permits. Such permits are issued for scientific and educational purposes only. The collected specimens and other materials and components of such specimens and materials may not be used for commercial or other revenue-generating purposes. Parties proposing commercial use of research results must enter into an agreement to share benefits with NPS or an agreement in which NPS explicitly declines to share benefits. In accordance with the National Parks Omnibus Management Act of 1998, which authorizes the Secretary of the Interior to enter into

negotiations with the research community and private industry for equitable, efficient benefits-sharing arrangements, NPS has developed policies and procedures to implement benefits sharing. For each benefits-sharing agreement, NPS proposes to choose an applicable agreement type from among several available authorities. The CRADA, authorized by the FTTA, is one such option.[11]

Air-quality Monitoring in Big Bend National Park. Big Bend National Park signed a CRADA with Texas Commission on Environmental Quality (TCEQ) in late FY 2022 and work began under the CRADA in FY 2023. Monitoring and managing air quality is part of the NPS mission. As a designated Class I Air Quality Area under the 1977 Federal Clean Air Act amendments, Big Bend has a particular interest and responsibility to monitor, protect, and enhance air quality. The park management needs data to support specific scientific objectives in assessing visibility and particulate matter in the atmosphere. TCEQ is the agency within the State of Texas responsible for managing the State network of particulate matter monitoring stations under the Federal Clean Air Act. TCEQ's goal is the collection of air pollution data that are representative of ambient conditions surrounding each monitoring site and within the certainty limits specified in their yearly Quality Assurance Project Plans.

[11] For further information on NPS benefits sharing, see Benefits Sharing in the National Parks (U.S. National Park Service) (nps.gov). URL: https://www.nps.gov/nature/benefits-sharing.htm

NPS SITE OPERATOR KELON CRAWFORD PERFORMS MONTHLY VERIFICATIONS ON THE CAMS 316 MONITORING STATION IN BIG BEND NATIONAL PARK. IN FY2023, THIS STATION COLLECTED DATA ON AIR POLLUTION; WIND SPEED, DIRECTION, GUST, AND STANDARD DEVIATION OF HORIZONTAL WIND DIRECTION; AND OUTDOOR TEMPERATURE. PHOTO: NPS/STAFF.

Under the CRADA, particulate matter monitoring at the "Bravo Big Bend" air monitoring site (CAMS 316) accomplishes the objectives of both Parties by providing continuous data on particulate matter as well as meteorological data in a remote region of the State where the nearest similar monitoring station is over 200 miles away. TCEQ provides all air monitoring equipment, parts, audit equipment, gas standards, sample media, data collection equipment, and equipment-related supplies for the proper operation of the air monitoring stations. Park employees operate and maintain the air monitoring stations within Big Bend according to all applicable rules and guidelines. By providing data from this remote area of the State, NPS and TCEQ will be able to identify any problems with air quality in the Big Bend region and take

action to address it, protecting the health of Texas residents and park visitors from all over America and the world.[12]

A RAINBOW OF COLORS AT THE NORRIS GEYSER BASIN, YELLOWSTONE NATIONAL PARK. RESEARCH ON MICROORGANISMS FOUND IN THE EXTREME ENVIRONMENTS CREATED BY YELLOWSTONE THERMAL FEATURES HAVE LED TO SOME DISCOVERIES WITH PRACTICAL APPLICATIONS OF GLOBAL SIGNIFICANCE. NORRIS, ONE OF THE HOTTEST AND MOST ACIDIC OF YELLOWSTONE'S HYDROTHERMAL AREAS, HARBORS MICROBES OF INTEREST TO DIVERSE RESEARCHERS—FROM ASTROBIOLOGISTS TO FOOD SCIENTISTS. SOURCE: NPS/NEAL

Benefits-sharing Agreement. Yellowstone National Park has a nontraditional CRADA, ongoing in FY 2023, with a small business that is commercializing research results from a study of microbial mats collected from a thermal area in the park. Food products based on its research are currently available in stores nationwide, and online via Amazon. The company is providing nonmonetary benefits related to a genetic monitoring program for the purpose of disease detection and conserving genetic diversity of park wildlife. The company will provide monetary benefits to the park upon successful commercialization of products or services it develops based on its discoveries.

[12] General information about the Texas Air Monitoring System Information is available at https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome. Data from the Big Bend monitoring site (CAMS 316), are available at https://www.tceq.texas.gov/cgi-bin/compliance/monops/monthly_summary.pl.

X. Bureau of Reclamation

The Bureau of Reclamation is a water management agency whose mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Reclamation is the largest supplier and manager of water in the 17 western States and the Nation's second-largest producer of hydroelectric power. Reclamation manages water for agricultural, municipal, and industrial uses and provides flood risk reduction and recreation for millions of people.

SHASTA DAM ON THE SACRAMENTO RIVER. RECLAMATION PROJECTS LIKE SHASTA DAM PROVIDE WATER, POWER, RECREATION, AND FLOOD PROTECTION TO MILLIONS OF AMERICANS. PHOTO: BUREAU OF RECLAMATION

Reclamation's management and recreation activities contribute more than $34.1 billion to the economy and support 450,700 jobs.[13] Reclamation provides western farmers with irrigation water for 10 million farmland acres that produce 60 percent of the nation's vegetables and one quarter of its fresh fruit and nut crops. Further, Reclamation delivers about 10 trillion gallons of water to 31 million people for municipal, residential, and industrial use. Through the process of providing water deliveries, Reclamation also generates hydropower through 77 owned power

[13] Bureau of Reclamation, "About Us—Fact Sheet." Updated 1/19/2024. URL: https://www.usbr.gov/main/about/fact.html

plants, 53 of which are operated and maintained by Reclamation. The latter 53 power plants account for 15 percent of the hydroelectric generating capacity in the United States and generate roughly 40 billion kilowatt hours of electricity annually, which is enough to supply more than 3.8 million U.S. households.

HYDROPOWER TURBINES AT HUNGRY HORSE POWER PLANT NEAR HUNGRY HORSE, MONTANA. RECLAMATION FACILITIES PROVIDE HYDROPOWER FOR MILLIONS OF U.S. HOUSEHOLDS, AND ITS RESEARCH AND DEVELOPMENT WORK FINDS SOLUTIONS TO KEEP BOTH WATER AND POWER FLOWING. PHOTO: BUREAU OF RECLAMATION

Reclamation Research and Development. Reclamation's R&D is primarily focused on applications to identify and develop solutions related to the broad spectrum of water- and hydropower-related issues. Reclamation's R&D Office manages two appropriated R&D programs: the Science and Technology (S&T) Program and the Desalination and Water Purification Research (DWPR) Program.

The S&T Program is the primary R&D program for Reclamation and funds intramural research that spans the spectrum of its water-related technical challenges. Its goals are to identify and develop cost-effective solutions to the technical and scientific problems affecting the accomplishment of Reclamation's mission and to communicate those solutions to Reclamation offices, its stakeholders, other water and power management officials, and the general public. In addition to supporting internally led research, the S&T Program supports other program areas. S&T prize competitions enlists crowdsourced innovation to address some of Reclamation's most difficult challenges in infrastructure, water availability, and environmental compliance. S&T Snow Water Supply Forecasting aims to advance emerging technologies to enhance snow monitoring and subsequent water supply forecasts. Finally, S&T Facilitated Adoption supports the transition of promising research and prize outcomes into broader use throughout Reclamation.

The DWPR Program invests in extramural R&D that advances the capabilities of water treatment technologies to enable them to be used more broadly for the creation of new water supplies from non-traditional sources (e.g., seawater, brackish groundwater, produced waters from oil and gas, municipal and industrial wastewater), nationwide or even globally. Such new supplies can relieve water stress on western communities, Tribes, western river basins supporting Reclamation projects, the Nation as a whole, and worldwide in water-constrained areas. The program also supports the operation and maintenance of the Brackish Groundwater National Desalination Research Facility, which hosts Federal and non-Federal R&D clients conducting bench-scale studies to pilot-scale demonstrations.

Although Reclamation's R&D focuses on developing solutions that address Reclamation technical mission needs, such solutions can also have broad applicability beyond Reclamation's jurisdiction in the western United States. The transfer of Reclamation's technology and knowledge across the national and international communities of practice maximizes public benefits of Reclamation's R&D investments.

Most of Reclamation's R&D reports, data, and information on technology advancements are transferred through public dissemination via the R&D Office website[14] as well as through Reclamation's new open data sharing platform, the Reclamation Information Sharing Environment.[15]

[14] URL: www.usbr.gov/research

[15] URL: https://data.usbr.gov

Transfer of other technology advancements harnesses the capabilities and know-how of the private sector to mature, mass-produce, and otherwise commercialize the technology into market-ready products. Reclamation's research nexus with industry is typically in the area of hydroelectric power generation, water infrastructure, water conservation, and desalination/water purification technologies.

If an industry partner is needed to ultimately transfer the technology into a market-ready product, Reclamation utilizes the authorities available under Federal technology transfer legislation to protect intellectual property, as needed, and form research and licensing partnerships with U.S. manufacturing industries. Reclamation's R&D Office implements these authorities on behalf of the bureau and serves as the Bureau's Office of Research and Technology Applications (ORTA), as required by 15 USC § 3710(b).

Reclamation also works to increase awareness across U.S. industries and other nongovernmental organizations of the specialized research resources (people, lands, and facilities) that they can access through technology transfer agreements authorized by 15 USC § 3710a. In addition to physical research laboratories, Reclamation's R&D assets include engineering and scientific expertise, extensive water storage, water delivery, and hydropower facilities that offer unsurpassed, real-world laboratories for field tests, evaluations, and demonstrations of new technologies and processes related to water and hydropower. Although many of its R&D activities do not involve the development of patents or industry involvement to mature technologies into viable products, the technology transfer activities that Reclamation conducts under the authorities of the Federal technology transfer legislation are an important subset of its technology transfer responsibilities and help transfer technology more rapidly and broadly.

Highlights of Reclamation technology transfer activities during FY 2023 include the following:

Coupling Forward Osmosis with Ion Exchange. Ion exchange (IX) is among the best available technologies to treat water to meet potable water regulatory requirements, commonly used to remove nitrate, chromium, arsenic, uranium, and other problematic aqueous constituents. IX is enabled by running the contaminated water over a solid resin where exchange occurs, and contaminants are removed. Once exchange capacity has been exhausted, it is regenerated, typically by using a brine solution. For many systems the principal economic, environmental, and operational considerations relate to waste disposal of the brine used to regenerate the IX resin. Reducing the volume of IX waste brine would provide a cost savings for utilities by reducing disposal and handling costs associated to waste brine.

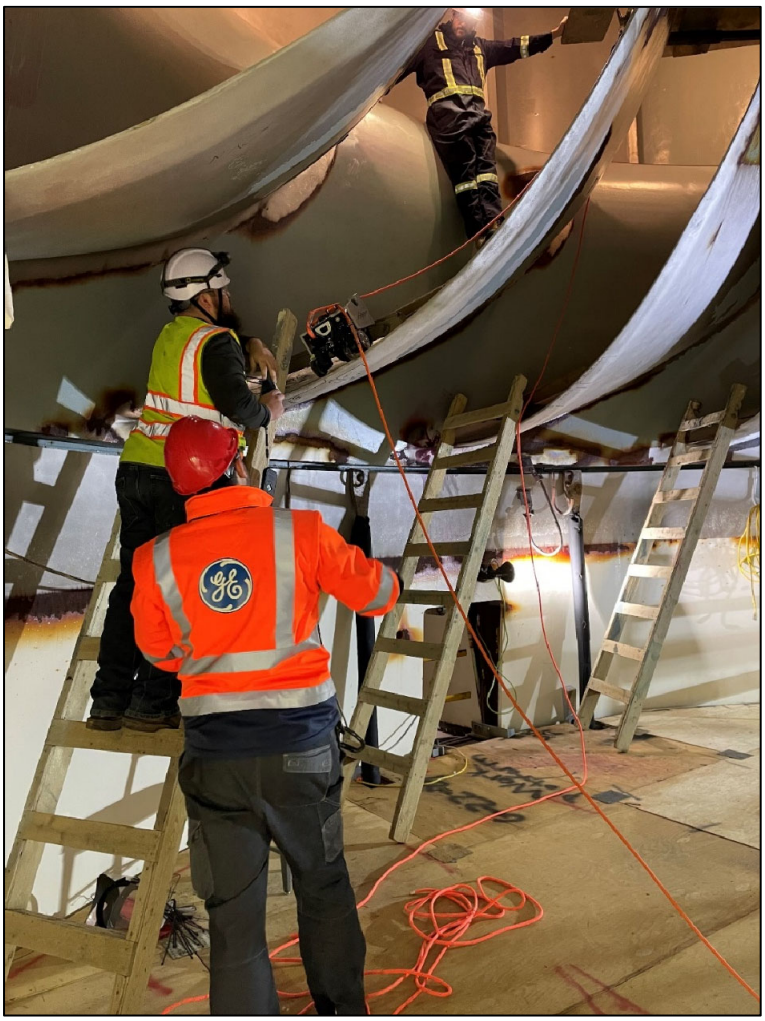
Forward osmosis (FO) uses a semi-permeable membrane to extract freshwater from IX waste brine using a “draw” solution which can subsequently be used for IX resin regeneration that has a higher osmotic pressure than the IX waste brine. The novel FO-IX process was developed and patented by Reclamation, which allows for waste reduction while extracting water for beneficial purposes. The passive osmotic gradient between solutions is the sole driving force to allow for the passage of water through the membrane. The FO process, therefore, uses minimal energy because the entire process can be accomplished with low-pressure recirculation pumps. This invention has the capability of reducing IX waste brine disposal cost by 60-80% depending on the application.

Reclamation has entered into a CRADA with Ayon Technologies Inc., who are in the process of field testing a prototype on a full-scale water treatment plant generated IX brine, with the intent of commercializing the process for large-scale implementation. An experimental plan has been developed and testing is slated to commence in FY 2024 where either a chromium or nitrate full-scale IX treatment facility has been identified as the test location.

Cavitation Detection Techniques for Optimizing Hydraulic Turbine Operation and Maintenance. Cavitation is a well-known destructive hydraulic phenomenon in which localized areas of static pressure fall below vapor pressure producing a liquid to vapor transition and collapse as water passes through the runner. High energies involved with vapor collapse cause turbine component material loss, extended repair outages, and shorted equipment lifespan resulting in reduced power generation. Across the hydropower industry, cavitation and unit operation within hydraulic induced vibration rough zones is a costly and complex problem to which drought-induced reservoir fluctuation is a contributor. Through a CRADA, ongoing in FY 2023, Reclamation and GE Vernova (GE) are performing research at Grand Coulee, Washington, to study cavitation and improve techniques to detect and map turbine cavitation, including runner erosion and fluctuating pressure-induced rough zone operations, with the goal of quantifying this damage so that operational ranges where these conditions occur can be avoided. Grand Coulee Unit G24, the test platform for this research, is an 805-megawatt hydroelectric generator located in eastern Washington State.

Initial tests conducted identified and mapped areas of inter-blade vortex cavitation, inlet suction cavitation, the hydraulic-induced turbine rough zone, and a particular operational area where damaging strong pressure surges were occurring within the turbine. Researchers found that these pressure surges could be effectively mitigated through air injection into the turbine. This research has culminated with the installation of separately designed Reclamation and GE cavitation monitors on Unit G24. These monitors have the ability to accurately detect, map, and trend cavitation activity occurring on the turbine runner. Current and past research is leading

toward the ultimate goal of advanced cavitation monitors that can accurately translate sensor activity to actual runner cavitation erosion damage. Other related on-going research activities include the study of air injection to mitigate cavitation related pressure pulsations, Remote Operated Vehicle (ROV) inspections to assess cavitation damage, better cavitation damage inspection assessment techniques and new research into the design and implementation of robotic welding.



GE PERSONNEL PERFORMING REMOTE-OPERATED VEHICLE CAVITATION INSPECTION MOBILITY TESTING ON GRAND COULEE UNIT G24. PHOTO: BUREAU OF RECLAMATION

XI. Bureau of Safety and Environmental Enforcement

The Bureau of Safety and Environmental Enforcement (BSEE) is America's lead agency charged with advancing safety and environmental protection and conserving natural resources related to energy development on the U.S. Outer Continental Shelf (OCS). BSEE's R&D focus is on offshore energy issues and activities. These activities primarily involve the Office of Offshore Regulatory Programs (OORP) and the Oil Spill Preparedness Division (OSPD).

OORP drives and supports continual improvement in safety, environmental protection, and offshore resource conservation through data and risk analysis, safety improvement initiatives, regulatory development and maintenance, standards and stakeholder engagement, policy development and oversight, and emerging technology evaluations.

OPSD ensures that owners and operators of offshore facilities are ready to mitigate substantial threats of, and respond to, oil spills that may result from their activities. OSPD performs numerous functions to improve oil spill preparedness and response capabilities including comprehensive contingency planning, equipment testing and inspection, quality training, unannounced exercises, R&D, and engaging with the stakeholders of the National Response System.

BSEE R&D programs operate through OORP's Emerging Technologies Branch (ETB) and OSPD's Response Research Branch. The ETB is the agency's focal point on operational safety and pollution prevention research. Such research has been conducted within Interior since the late 1970s. OSPD's Oil Spill Response Research in its Oil Spill Preparedness Program contributes to the interagency collaborative efforts formalized in Title VII of the Oil Pollution Act of 1990 and focuses on improving the methods and technologies used for oil spill detection, containment, treatment, recovery, and cleanup.

OSPD also operates Ohmsett, the National Oil Spill Response Research and Renewable Energy Test Facility in Leonardo, New Jersey. The Ohmsett facility provides independent and objective performance testing of full-scale oil spill response equipment and marine renewable energy devices. Additionally, the facility is available to help improve existing technologies through R&D, as well as train first responders on oil spill response equipment with oil in an environment simulating open water conditions. In 2022, OSPD initiated its Testing of Oil Spill Response Technology initiative as authorized in the Oil Pollution Act of 1990, Section 7001, to evaluate and test technologies at the Ohmsett facility. Innovative sorbent technologies were independently evaluated for performance using the U.S. Coast Guard's recently developed technology evaluation process. During the spring of 2023, testing of a wave energy conversion

device developed by the University of Cork, Ireland as part of the U.S. Department of Energy's Testing and Expertise for Marine Energy program was conducted in the Ohmsett wave tank.

The majority of BSEE's technology advances are shared with the public through reports that are publicly available on its website. In FY 2023, BSEE also continued to share its research results at conferences, workgroups, and other fora, such as the triennial International Oil Spill Conference, the annual Clean Gulf Conference, the Pacific States-British Columbia Oil Spill Task Force Annual Meeting, the National Response Team Science and Technology Committee, the Northern Oil and Gas Research Forum, the BSEE/U.S. Coast Guard (USCG) Response Work Group, BSEE/USCG Research Sharing meetings, industry meetings, and the Ocean Energy Safety Institute's Public Research Forum.

BSEE's research synergy is with State, Tribal, Federal, and international government organizations, the offshore energy industries, and oil spill removal organizations. Research is typically in areas pertaining to critical equipment and technology, environmental impact, and risk reduction and assessment tools and techniques applicable to the U.S. OCS to ensure that the best available science is utilized in regulatory decision-making.

BSEE is a member of the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR) and its Executive Steering Committee. Comprising 16 Federal agencies, ICCOPR was established by Title VII of the Oil Pollution Act of 1990 to "coordinate a comprehensive program of oil pollution research, technology development, and demonstration among the Federal agencies, in cooperation and coordination with industry, universities, research institutions, State governments, and other nations, as appropriate." ICCOPR publishes the Oil Pollution Research and Technology Plan that establishes the official Federal priorities to address research gaps in preparedness, prevention, response, and injury assessment and recovery for oil spills. Through FY 2023, BSEE led efforts by the Executive Steering Committee to publish the FY 2022-2027 Oil Pollution Research and Technology Plan.

BSEE is a member of the International Regulators' Forum, which consists of members from 11 countries whose goal is to provide leadership on safety and safety-related regulatory matters for offshore energy activities. Other members include Norway, Canada, Brazil, and the United Kingdom.

The following are examples of FY 2023 completed or ongoing research projects that would, among other things, advance technological options and transfer knowledge about best technological practices to industries and regulators operating on the OCS.

Subsea Bolt Study: Technical Gaps in Current Standards and Requirements. BSEE initiated research into bolt failures starting 2012 following a series of failures involving critical

equipment used by the offshore oil and gas industry. Since that time, BSEE contracted with Argonne National Laboratory to conduct several research projects relating to the bolt failures, and several of these reports were peer-reviewed and then released to the public in 2023. Additionally, BSEE has participated on the American Petroleum Institute (API) standards committees that updated two existing specifications and published one new standard in 2023 to address the bolt failures. API also has 14 specifications that now reference API 20E (Low Alloy Steel) and API 20F (Corrosion Resistant Alloy) as a requirement for critical bolting applications.

BSEE continues to monitor this issue. On March 27, 2023, BSEE issued Panel Report 2023-001 based on the BSEE investigation of a jumper stud failure that occurred in July 2020. The oil and gas industry has taken action, replacing nearly all of the bolts on all critical equipment on rigs operating in the Gulf of Mexico, including blowout preventers and lower marine riser packages.

FAILED BOLTS IN A HYDRAULIC CONNECTOR AFTER ONLY 4 MONTHS IN SERVICE AT 5,720 FEET OF WATER DEPTH. THIS CONNECTOR IS DESIGNED TO LINK A LOWER MARINE RISER PACKAGE AND A LOWER BLOWOUT PREVENTER, WHICH PREVENTS THE UNCONTROLLED DISCHARGE OF HYDROCARBONS FROM A WELL. PHOTO: BSEE QC-FIT REPORT #2016-04, FEBRUARY 2016.

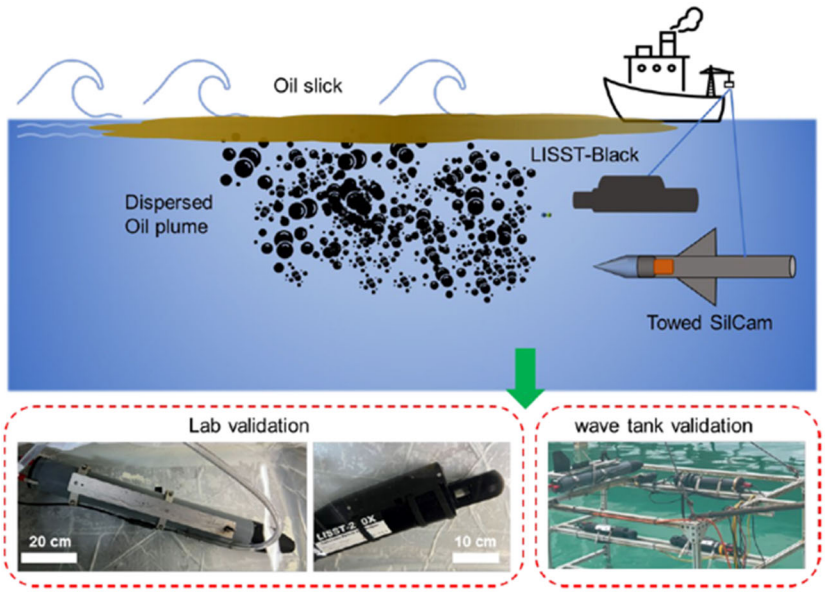
BSEE's ongoing efforts to conduct investigations, research, and industry and interagency outreach to address bolt failures have led to the formation of an Interagency Bolt Action Team, a group of subject matter experts from various industries who have relevant fastener expertise; experiences in failure analysis, research and development on the fastener types (bolts, studs,

nuts, screws, etc.), materials, and environment; and applied-best-practices knowledge for various industrial applications for enhanced performance of the fastener components. The subject matter experts observe and oversee the quality-assurance and quality-control procedures and assess equipment and systems for fitness of service. The Team shares the root causes of fastener incidents and near-miss events and recommends solutions such as the implementation of newer materials and/or technologies that may be applied to promote safety of the equipment and protect the environment.

These efforts are not only leading to greatly enhanced performance and reliability for fasteners used by the offshore oil and gas industry, but also for critical fasteners used by a wide range of other industries as well as civilian government agencies and the military.

BSEE Oil Spill Response Research Testing & Evaluation Phase. The Program uses customized technology readiness level milestones to ensure our technologies are sufficiently mature to withstand the rigors of offshore deployment. The unique challenge for Oil Spill Response Research R&D to transfer or commercialize its technology is that, within the oil spill response community, there is rarely a business case justification for an oil spill response organization to willingly adopt these technologies, as it costs money but doesn't improve profitability. To address the risk of deploying unproven technology during an actual oil spill, offshore testing and evaluation of technologies in the final stages of the technology readiness level ladder were underway in FY 2023. It is important to note that no oil is used during testing and evaluation events; technologies are deployed to evaluate their ruggedness and readiness for potential use in the event of an unintentional spill. The two initial technologies include instrumentation to measure the droplet size of chemically dispersed oil at the surface of the ocean and a technique to reduce the emissions and burn residue associated with *in situ* burning of oil on the ocean.

Surface Water Droplet Size Distribution Instrument Evaluation. This research involves the evaluation of existing technology to detect and measure oil droplet size distribution in depths of one to five meters. The initial phase comprised the procurement of the instruments and laboratory validation to assess instrument sensor accuracy. The second phase assessed the deployment capability of these instruments at the Ohmsett wave tank to identify an appropriate carriage system sufficiently rugged for offshore ocean vessel deployment in both static and towed configurations, as well as the ease of use of instrumentation software and posted data processing. The final phase involved offshore deployment to test and evaluate the ability of the droplet size distribution system, including the stainless-steel frame, instruments, cables, and laptops with the software, to be safety deployed from ocean-going vessels. The outcomes of this research will inform BSEE preparedness analysts and the oil spill response community as to the ability of the current available technology to meet the stipulations of Subpart J of the National Oil and Hazardous Substances Pollution Contingency Plan.



A DIAGRAM SHOWING THE OVERALL TESTING APPROACH FOR LAB, TANK AND FIELD EVALUATION OF DSD INSTRUMENTATION. SOURCE: BSEE.

Linear Burn Configuration "Restricted Burning Tongue" for Improved Burning Efficiencies. In FY 2023, BSEE continued advancement of its research to create cleaner burns of crude oil with fewer harmful emissions and reduced unburned oil residues. *In situ* burning of oil is a highly effective response option for oil spills; however, the smoke plume from incomplete combustion and soot product along with burn residues are significant drawbacks. Further, fire boom systems are exorbitantly expensive with limited uses before they are consumed by the fires. This research developed a prototype to reconfigure existing fire booms already in oil spill response organizations' inventories to reduce emissions and burn residues rendering an already efficient response method even more efficient. Testing on the open ocean is not permissible; however, mesocosm tests resulted in a 21% increase in how well the oil burned, and particulate matter decreased with this increased combustion efficiency. The fire boom is reconfigured into a "wine glass" geometry where the boom collects the floating oil in the cup portion of the system and releases it for burning in the stem portion. The narrow stem allows for greater intake of oxygen into the flames allowing for more complete combustion. Mesocosm tests for burn and combustion efficiency were conducted at the U.S. Army Corps of Engineers' Cold Regions Research and Engineering Lab and for operationalization at Ohmsett. Reductions in both emissions and unburned oil volumes were achieved. Testing and evaluation of the system for ruggedness and operationalization in realistic open water conditions for transfer and socialization of the concept to the oil spill response community occurred offshore Louisiana in cooperation with potential end users of the technology.

TOP LEFT: A BURN TEAM DURING THE MACONDO WELL LEAK RESPONSE IN 2010. PHOTO: ELASTEC. TOP RIGHT: TESTING OF A RECONFIGURED BURN SYSTEM CONCEPT AT OHMSETT. PHOTO: ELASTEC. BOTTOM: CRUDE OIL BURN TESTS OF THE RECONFIGURED BURN SYSTEM AT CRREL. THESE TESTS RESULTED IN REDUCED EMISSIONS WITH LESS BURN RESIDUE. PHOTO: BSEE.

Testing of Oil Spill Technology Skimmer Tests in Dielectric Fluids. In FY 2023, BSEE's Oil Spill Preparedness Division partnered with the U.S. Coast Guard Research and Development Center to gain insight into the recovery of dielectric fluids as part of its Testing of Oil Spill Response Technology initiative, which evaluates oil pollution mitigation technologies to provide performance data to stakeholders. With the significant increase in offshore wind energy facility construction near U.S. coastlines, there is an environmental risk of dielectric fluid spills from the electrical service platforms and wind turbines. Four skimmers were selected for evaluation based on equipment listed in preliminary oil spill response plans form offshore wind facilities and discussions with oil spill removal organizations. The skimmers were tested on two categories of dielectric fluid common for offshore wind turbine operations. The soon-to-be-published report captures all findings and presents conclusions and recommendations to Federal On-Scene Coordinators on how existing oil skimmers should be used for dielectric fluid spills. The report will also spur improvements to oil skimmer technology.

ELASTEC KVICHAK VESSEL WITH AN X30 GROOVED DISC SKIMMER COLLECTING DIELECTRIC FLUID IN A TEST POOL. THIS TECHNOLOGY IS DESIGNED TO HELP RECOVER POLLUTANTS DISCHARGED FROM OFFSHORE WIND TURBINES. PHOTO: BSEE

XII. Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) manages the Nation's offshore energy, mineral, and geological resources in an environmentally and economically responsible way. It ensures access to, and the fair return from the development of, conventional and renewable energy and mineral resources of the U.S. OCS to help meet the Nation's energy and mineral needs while protecting the human, marine, and coastal environments and addressing climate change.

As one of the Nation's offshore energy and mineral resource managers, BOEM is committed to using the best available science and knowledge across a range of relevant disciplines that provide the scientific and technical foundation and the human capital needed to make sound decisions at all levels of the organization. Management of the energy and mineral resources of the OCS is governed by the OCS Lands Act, which establishes procedures for leasing, exploration, and development and production of those resources, including oil, gas, renewable energy, and marine minerals such as sand and gravel used for coastal restoration projects.

BOEM conducts and publishes environmental reviews, including National Environmental Policy Act analyses and compliance documents, for each major stage of resource planning and development. These analyses are carried out by BOEM's Office of Environmental Programs,[16] Office of Renewable Energy Programs,[17] and its regional offices.[18] These analyses inform BOEM's decisions on its National OCS Oil and Gas Leasing Program and other energy and mineral leasing and development activities. In addition, BOEM's scientists conduct and oversee environmental studies to support decisions relating to the management of energy and marine mineral resources on the OCS through its Environmental Studies Program (ESP).

BOEM's three regional offices—located in New Orleans, Louisiana; Camarillo, California; and Anchorage, Alaska—manage oil and gas resource evaluations; renewable energy development; environmental studies and assessments; leasing activities; reviews of required plans submitted by lessees; fair market value determinations; and geological and geophysical permitting.

BOEM manages the exploration and development of the Nation's offshore resources in a way that appropriately balances economic growth, energy development, and environmental

[16] URL: http://www.boem.gov/Environmental-Stewardship

[17] URL: http://www.boem.gov/renewable-energy

[18] URL: http://www.boem.gov/regions

protection. BOEM's ESP strives to apply the best science and knowledge available for informed decision-making. It plans, conducts, and oversees world-class scientific research to inform policy decisions regarding leasing and developing OCS energy and mineral resources. BOEM's environmental studies cover a broad range of disciplines, including archaeological resource protection, physical oceanography, meteorology and air sciences, biology, protected species, social sciences and economics, submerged cultural resources evaluation, and the overall environmental effects of energy and mineral development. BOEM continues to be a leading contributor to the growing body of scientific knowledge about the Nation's marine and coastal environment.

BOEM oversees scientific research conducted through contracts, partnerships, and cooperative or other agreements with other Federal agencies, Tribes, State institutions, and universities. These arrangements enable the bureau to leverage resources, meet national priorities, and satisfy common needs for robust scientific information. Many of the bureau's studies are collaborations with partners under the umbrella of the National Oceanographic Partnership Program.

BOEM's technology transfer activities include disseminating information, knowledge, and technologies to commercial entities and other stakeholders with interests in the OCS. Virtually all these activities are undertaken using authorities provided to BOEM other than the FTTA. Studies undertaken or funded by BOEM are available to the public through the BOEM environmental studies website.[19] The website includes 193 ongoing and 2089 completed BOEM-sponsored environmental research projects and provides online access to more than 3,946 research reports. In 2023, ESP completed 24 studies that accounted for approximately $34 million in BOEM-funded ocean research.

BOEM also partners with BSEE to select and fund renewable energy research to facilitate industry development, promote operational safety, and prevent pollution through BSEE's Technology Assessment Program.[20]

BOEM participates in and funds interdisciplinary projects, including partnerships with other Federal agencies, academic institutions, and the private sector. These projects are directed toward offshore ecosystem studies that utilize state-of-the-art technologies, such as autonomous underwater vehicle surveys, deep-water human-occupied submersibles, and

[19] URL: https://www.boem.gov/environment/environmental-studies/environmental-studies-information

[20] More information on this research is available at https://www.boem.gov/Technology-Assessment/.

remotely operated vehicles. These partnerships leverage expertise and technologies to meet common management goals.

The following are a few examples of BOEM's scientific R&D activities initiated or ongoing in FY 2023, including some conducted in cooperation with other parties.

Artificial intelligence competition improves beluga whale aerial image analysis. BOEM partnered with the National Aeronautics and Space Administration and the National Oceanic Atmospheric Administration (NOAA) to carry out the "Where's Whale-do?" machine learning competition, providing funding and subject matter expertise to help improve automatic identification of beluga whale individuals from aerial photographs of the ocean surface. NOAA regularly collects aerial imagery to detect beluga whales in Cook Inlet, Alaska, in order to protect this sensitive species. Assigning IDs to individual whales from aerial images greatly improves beluga whale population management, as this enables mark recapture estimates for demographic analysis. Individual identification from aerial imagery depends on patterning on the beluga's dorsal surface, and signal and noise issues made this challenging for NOAA to do precisely and at scale in the past. Contestants were asked to use the latest machine learning, artificial intelligence technology to precisely identify individual belugas. The best solutions from the contest were identified and their ideas were deployed in 2023 and are now capable of improving beluga whale population estimates, allowing scientists to manage and protect this species more effectively. Further, these methodological improvements are also being considered for improving management of other whale species.

Environmental monitoring for responsible renewable energy development activities. BOEM carried out monitoring during the construction and operation of two monopile wind turbines off the coast of Virginia as part of its Real-Time Opportunity for Development Environmental Observations (RODEO) Program. Underwater acoustic, turbidity, biofouling, and corrosion monitoring helped BOEM understand environmental considerations for wind farm construction and operation. For example, RODEO designed an experiment to test the mitigation measures for sound produced during wind farm construction. RODEO measured sound levels during underwater pile driving while a bubble curtain treatment was being employed and during control periods without any mitigation in place. This research, which completed its reporting in 2023, will help BOEM evaluate and improve its environmental protections not only along the coast of Virginia, but also any wind energy area across the nation where similar environmental protections may be employed.

RV VIRGINIA APPROACHING ONE OF THE COASTAL VIRGINIA OFFSHORE WIND (CVOW) MONOPILE WIND TURBINES TO DEPLOY RODEO RESEARCH INSTRUMENTS. PHOTO: COTTER MP

Vibroacoustics Studies. BOEM planned studies on the substrate borne propagation and the behavioral responses of marine life to sound produced from offshore renewable energy development. This work extends previous monitoring activity of the Block Island Wind Farm and coastal Virginia projects that measured underwater sound and vibration. A workshop funded in FY 2023 will review the literature and state of the art physical and biological science methodologies to help BOEM plan appropriate studies, including a physical and biological study. The physical study would seek valuable insights on the physical characteristics and propagation of various substrate-borne vibroacoustic disturbances through field measurements and numerical modeling during wind turbine pile driving. The behavior study would examine the potential behavioral and physiological effects of particle motion and substrate-borne vibration on susceptible species by examining: 1) multiple fish and invertebrate species; and 2) a suite of behavioral and physiological responses—acute, chronic, and/or biologically meaningful. The data from these two studies would be used to analyze and understand

potential biological effects from offshore renewable energy development and to design improved mitigation measures for future wind farm construction and operation plans.

Innovative technique to measure coastal currents in Beaufort Sea and Lower Cook Inlet, Alaska. BOEM's Alaska Region awarded a cooperative agreement to the University of Alaska Fairbanks to research methodologies that could improve the measurement of ocean currents in the Alaska OCS using Current and Pressure Recording Inverted Echosounders. This technology is already being used to measure currents in parts of the ocean that are deeper than 500 meters, but through instrumentation improvements that increase the signal to noise ratio, this cost-effective method may be used in shallower shelf areas of the Beaufort Sea and Lower Cook Inlet. This research, ongoing in FY 2023, is beneficial for BOEM's management of the Alaska OCS, because data on currents is sparse for this region. Increasing the data coverage in shallow areas under BOEM's jurisdiction will improve the accuracy of regional ocean models and enhance the state of knowledge of the regional ecosystem impacts from climate change.

Innovative protected species observer technique for better nighttime mitigation. BOEM protects marine mammals and sea turtles by requiring monitoring and mitigation of development activities if protected species are observed in the project area. However, monitoring is prohibitive to nighttime development activities, and this is an issue that has been raised by industry partners for consideration by BOEM. Therefore, in FY 2023 BOEM funded an environmental study to test the efficacy of thermal camera imaging as an alternative observing technique for nighttime monitoring for protected species. Thermal imaging has been developed for marine mammal observing with a capability to detect marine mammals up to 2.5 km from an observer, and may be effective for mitigating nighttime geophysical, sand dredging, and trawling activities, which could potentially impact sea turtles, as well. The objectives are to develop a monitoring methodology that is likely to detect protected species that enter the project area at night, and to measure the efficacy of the nighttime observing technique compared to visual observation methods used during daylight hours.

XIII. Bureau of Land Management

The BLM manages approximately 245 million surface acres and 700 million subsurface acres in the United States. BLM's multiple-use and sustained yield mandate directs the management of public land resources for a variety of uses, such as recreation, wildlife conservation, energy and minerals development, wilderness, livestock grazing, clean water, and timber harvesting, while also protecting a wide array of natural, cultural, scientific, and historical resources for the use and enjoyment of present and future generations. To support its mission, the BLM annually conducts and supports hundreds of research and development projects with diverse entities such as Cooperative Ecosystem Studies Units; colleges and universities; scientific societies and institutes; national laboratories; museums; botanic gardens and arboretums; Federal, State, and Tribal government agencies; non-governmental organizations; and the private sector. These projects advance the state of knowledge and technology concerning all aspects of BLM resource management, and transfers those advances to entities and people outside the BLM through publication of reports, technical references, scientific journal articles, data releases, fact sheets, presentations, web-based products, books, and more. Examples of FY 2023 technology transfer activities include the following bureau-wide and program-specific efforts.

BLM Library and Publishing. BLM provides essential support to technology transfer by offering a full range of publication services encompassing research support, consultation, and planning; writing and editing; design and layout; external publication; and coordination of printing and distribution. Librarians, writer/editors, visual information specialists, and printing specialists work in concert to provide publication assistance for a broad spectrum of BLM communication products. The BLM Library[21] provides streamlined access to scientific information to BLM professionals, partners, and the public, with nearly 36,000 searches performed in FY 2023.

Assessment, Inventory, and Monitoring (AIM). High-quality data are essential to keeping public lands healthy. BLM's AIM Strategy[22] is a standardized process to collect quantitative information on the status, condition, trend, amount, location, and spatial pattern of natural resources on the Nation's public lands. Approximately 6,725 AIM data points in upland, river & stream, and riparian & wetland systems were sampled in 2023. From the data collected, calculated indicators of rangeland health are shared publicly via the BLM Geospatial Business

[21] https://www.blm.gov/learn/blm-library

[22] URL: https://www.blm.gov/aim

Platform Hub AIM Page.[23] AIM data are used by the BLM and a wide variety of Federal and State agencies, universities, nongovernmental organizations, private industry, and the public.

Also in FY 2023, Riparian & Wetland AIM reached a major milestone in standing up its own Spatial Database Engine database, adding data for 462 new sampling locations available on the Riparian & Wetland AIM Data Portal. Data for the Landscape Monitoring Framework,[24] an affiliated AIM sampling protocol, were also included for an additional 18,250 sampling locations published along with Terrestrial AIM data. Through AIM's science partner at the National Aquatic Monitoring Center, benthic macroinvertebrate samples have been processed, analyzed, and associated data stored in databases for 725 AIM sites and 45 non-AIM sites. AIM also shared data collection forms with about a dozen external requestors – a slight increase over the previous year.

[23] URL: https://gbp-blm-egis.hub.arcgis.com/pages/aim

[24] URL: https://gbp-blm-egis.hub.arcgis.com/datasets/ead231b9b88e4fdfbd16321d0fb0f86f_0/explore

XIV. Joint Fire Science Program

The Joint Fire Science Program (JFSP)[40], initiated in 1998 is a joint Interior and U.S. Department of Agriculture Forest Service (USDA FS) program. JFSP provides funding and science delivery for scientific studies associated with managing wildland fire, fuels, and fire-impacted ecosystems to respond to emerging needs of managers, practitioners, and policymakers from local to national levels. The JFSP is hosted by the BLM and overseen by a 12-member Governing Board with representation across Interior bureaus the Department (BIA, BLM, FWS, NPS, and the USGS) and FS. In FY 2023, the JFSP received $12.9 million in funds from Interior and USDA FS (some funding from the BIL and the Infrastructure Investment and Jobs Act). Funds are distributed via an annual cycle of open, competitive, peer-reviewed proposal solicitations for current wildland fire research priorities in three categories – science delivery and exchange, primary research, and graduate research innovation. All three categories will advance the science of fire management to enhance public safety and ecological health.

MAP OF THE REGIONAL FIRE SCIENCE EXCHANGES THAT MAKE UP THE FIRE SCIENCE EXCHANGE NETWORK. THESE EXCHANGES BRING TOGETHER FIRE MANAGERS, PRACTITIONERS, AND SCIENTISTS TO ADDRESS REGIONAL FIRE MANAGEMENT NEEDS AND CHALLENGES, IMPROVING FIRE SAFETY AND ECOLOGICAL HEALTH. SOURCE: JOINT FIRE SCIENCE PROGRAM

Science Delivery and Knowledge Exchange. The JFSP provides leadership to the fire science community by identifying high-priority fire science research to meet management objectives. Transferring research findings to managers, practitioners and policymakers is a key focus area for the program, and that is managed through the JFSP's 15 regional fire science exchanges

called the Fire Science Exchange Network (FSEN). Exchanges are successful in sharing, synthesizing, interpreting, demonstrating, and validating science products to facilitate science integration with on-the-ground land management. The network is a national collaboration that provides the most relevant, current wildland fire science information to stakeholders. The exchanges bring together fire managers, practitioners, and scientists to address common needs and challenges. Technology transfer is delivered through a variety of means, including webinars, training, field trips, research syntheses, workshops, social media, newsletters, etc.

In FY 2023, the JFSP:

- Produced 257 newsletters;
- Published 93 blog posts;
- Hosted 94 webinars;
- Developed 26 syntheses;
- Hosted 107 conferences/workshops;
- Developed 44 short courses and continuing education units; and
- Created 104 video productions.

Approximately 23,000 individuals participated in FSEN organized wildland fire science delivery activities in FY 2023.

JFSP Research Projects Completed in FY 2023. Researchers complete JFSP-funded research in a 2–3-year time frame. Upon completion, each research team submits a final report that includes project objectives, main findings, discussion, and next steps. In FY 2023, 23 reports were received (Table 1). Final reports can be accessed via the Research Tab on JFSP's website.[25]

[25] URL: https://www.firescience.gov/.

TABLE 6: JFSP FINAL REPORTS COMPLETED IN FY 2023.

JFSP Focused Need/Category	Report Title
Graduate Research Innovation	Does high-severity patch structure scale consistently with fire size across the Northwest US?
	Low-cost UAS platforms to quantify and predict post-fire recovery in arid shrublands
	Less fuel for the fire: How will drought amplify effects of short-interval fire?
	Demand for prescribed fire on private lands in the Mid-Atlantic United States
	Impacts of historical disturbance regimes on avian conservation in eastern tallgrass prairies
	Prescribed fire effects on soil hydraulic properties and ecohydrological function
Science Delivery and Knowledge Exchange	The Alaska Fire Science Consortium: Meeting the needs and challenges of wildfire managers in Alaska
	Great Basin Fire Science Exchange
	The Pacific Fire Exchange: Linking fire science and fire management in Hawaii and the US-Affiliated Pacific Islands
	Great Plains Fire Science Exchange
	Southern Rockies Fire Science Network
	Northern Rockies Fire Science Network
	Oak Woodlands Fire Science Exchange
	Northwest Fire Science Exchange
	The Southern Exchange: Putting fire science on the ground
	Developing a Southwest Fire Science Consortium
	Consortium of Appalachian Fire Managers and Scientists
Graduate Research Innovation	Accelerating post-fire restoration with a novel fungicide and abscisic acid seed coating formulation
	Fire-herbivore-climate dynamics in the Northern Great Plains
Fuel Treatments	Fuel break systems: Contrasting metrics and evaluative criteria for northern and southern California
Fire Effects and Fire Ecology	Pyrogenic controls on grass-shrub persistence in the Great Plains
	Long-term SUCCESS: Succession and ecosystem dynamics in the sagebrush steppe following wildfires
Other Projects	JFSP data management plan

JFSP-Approved FY 2023 Research. In FY 2023, JFSP focused research dollars on key scientific needs; in particular – 1) longevity of fuel treatment effectiveness under climate change (eight projects), 2) fuels treatment effectiveness across landscapes (nine projects), 3) pre-fire management actions for reducing post-fire hazards (three projects) and 4) social and political factors that influence fire suppression and rehabilitation costs (one project). In FY 2023, JFSP funded 21 research projects out of 35 proposals received.

FY 2023 highlights include:

- Longevity of fuel treatment effectiveness under climate change. The objectives of this task statement are to (1) understand patterns of fuel accumulation, vegetation change, and potential fire behavior following fuel treatments over time and (2) inform the frequency and type of treatments needed to maintain treatment effectiveness.
- Fuels treatment effectiveness across landscapes. The objective of this task statement is to inform planning and implementation of landscape fuel treatment strategies that allow for safe and effective management of wildfire to meet protection and resource management objectives.
- Pre-fire management actions for reducing post-fire hazards. The objective of this task statement is to gain better understanding of the factors that lead to successful cross-jurisdictional pre-fire planning aimed at reducing the potential for post-fire hazards, through synthesis and evaluation of existing tools and investigations of enabling conditions that foster successful cross-jurisdictional planning and action.
- Social and political factors that influence fire suppression and rehabilitation costs. The objective of this task statement is to evaluate understudied factors that influence costs associated with wildfire suppression and immediate post-fire rehabilitation to inform cost models and performance metrics for efficient use of fire suppression and rehabilitation resources.

Graduate Research Innovation. Graduate Research Innovation (GRIN) awards are meant to supplement already approved thesis or doctoral work by adding a component that addresses the management or policy relevance of the research. In FY 2023, 30 proposals were received, of which 20 proposals were selected for funding. Funded projects focused on:

- Fuel management and fire behavior;
- Changing fire environment;
- Emissions and air quality;
- Fire effects and post-fire recovery;
- Relative impacts of prescribed fire versus wildfire; and
- Human dimensions of fire.

XV. Conclusion

During FY 2023, Interior's technology transfer activities provided critical information and technologies to improve our understanding of and ability to address key issues such as climate change, drought, wildland fire, and threatened and endangered species. During FY 2023, the Department's technology transfer activities included the following activities:

- Engaged in 34 CRADAs and at least 1,669 other collaborative R&D relationships.
- Disclosed 10 new inventions, filed no new patent applications, and received no new patents.
- Managed 135 active licenses for inventions and other intellectual property, which collectively earned $76,794.
- Published over 3,400 reports, books, papers, fact sheets, and other documents.

XVI. Data Appendix

The following tables provide cumulative data for the Department from FY 2019 through FY 2023. Data for individual bureaus are available online.[26]

Data are provided if they are collected and readily available. Note that a blank cell or "N/A" indicates either zero, the data are not collected, or the data are otherwise unavailable. These tables include updates to previous years' data, where appropriate.

Table 1: Disclosures and Patents

		FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
	Invention Disclosures					
1	Invention Disclosures Received	8	4	2	3	10
2	Total Patent Applications Filed	3	4	1	3	0
3	*US*	0	2	1	3	0
4	*Foreign*	0	0	0	0	0
5	Total PCT Applications Filed. (**NOTE**: PCT = Patent Cooperation Treaty. See https://www.wipo.int/pct/en/)	0	0	0	0	0
6	Number of patents Issued	1	3	1	1	0
7	*US*	0	0	1	1	0
8	*Foreign*	0	0	0	0	0

[26] URL: https://www.doi.gov/techtransfer/annual-reports

Table 2: Licenses

		FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
9	Invention Licenses, Total Active	2	2	10	11	74
10	*New Invention Licenses*	0	0	2	2	2
11	*New Invention Licenses to Small Businesses*	0	0	1	2	2
12	Income bearing licenses, Total Active	16	14	9	10	13
13	*New Income Bearing Licenses*	0	0	1	2	0
14	*Exclusive licenses*	7	7	8	9	10
15	*Partially exclusive licenses*	0	0	0	0	0
16	*Non-exclusive licenses*	9	6	2	2	3
17	Other Licenses, Total Active	0	0	48	61	61
18	*New Other Licenses*	0	0	42	13	6
19	*New Other Licenses Granted to Small Businesses*	0	0	40	10	0
	Elapsed Amount of Time for Granting Invention Licenses					
20	Average (months)	7	7	30.5	7	2.5
21	Minimum (months)	7	7	29	5	2
22	Maximum (months)	7	7	32	9	3
23	Licenses terminated for cause	0	1	1	0	0

Table 3: License and Royalty Income

		FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
24	**Invention License Income**	$42,168	$122,749	$67,694	$108,761	$76,794
25	**Other License Income**					
26	**Total Earned Royalty Income (ERI)**	$42,168	$122,749	$67,694	$107,761	$76,794
27	*ERI from top 1% of licenses*			$53,630	$98,356	$55,656
28	*ERI from top 5% of licenses*			$53,630	$98,356	$55,656
29	*ERI from top 20% of licenses*			$53,630	$98,356	$62,793
30	Minimum Earned Royalty Income			$3,195	$25,000	$1,000
31	Maximum Earned Royalty Income			$53,630	$98,356	$36,111
32	Median Earned Royalty Income			$10,925	$19,302	$4,500
	Disposition of ERI					
33	Percent of ERI distributed to inventors	64%	39%	36%	33%	33%
33A	Amount of ERI distributed to inventors	$27,121	$47,872	$24,045	$35,561	$25,342
34	Percent of ERI distributed to the agency or laboratory	36%	34%	37%	33%	33%
34A	Amount of ERI distributed to the agency or laboratory	$15,047	$41,735	$24,762	$35,561	$25,342

Table 4: CRADAs

		FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
	CRADAs					
35	Total Active CRADAs	470	489	429	32	34
36	New CRADAs	352	237	139	5	2
37	New CRADAs Involving Small Businesses	2	2	1	1	0
	Other collaborative R&D relationships					
38	Other Collaborative Agreements, total active in the FY	269	353	625	1,034	1,669

XVII. Acronyms and Abbreviations

AADAP	Aquatic Animal Drug Approval Partnership Program
ACP	American Clean Power Association
AIM	Assessment, Inventory and Monitoring
AIS	Aquatic Invasive Species
AML	Abandoned mine lands
ANL	Argonne National Laboratory
ASP	Applied Sciences Program
AUV	Autonomous underwater vehicle
AWEA	American Wind Energy Association
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BOR	Bureau of Reclamation
BSEE	Bureau of Safety and Environmental Enforcement
CAMS	Continuous Ambient Monitoring Station
CESU	Cooperative Ecosystem Studies Units
CRADA	Cooperative Research and Development Agreement
CVOW	Coastal Virginia Offshore Wind
DNA	Deoxyribonucleic acid
DOE	U.S. Department of Energy
DOI	Department of the Interior
DSD	Droplet size distribution
DWPR	Desalination and Water Purification Research
e-AMLIS	Electronic Abandoned Mine Lands Inventory System
eDNA	Environmental DNA
EDRR	Early detection and rapid response
EPA	U.S. Environmental Protection Agency
ERI	Earned Royalty Income
ESA	Endangered Species Act
ESP	Environmental Studies Program
ETB	Emerging Technologies Branch
FAC	Fish and Aquatic Conservation
FO	Forward osmosis
FSEN	Fire Science Exchange Network
FTC	Fish Technology Center
FTTA	Federal Technology Transfer Act of 1986
FUSA	Facility Use/Service Agreement
FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year

GIS	Geographic information system
GRIN	Graduate Research Innovation
GSB	Geospatial Services Branch
IBAT	Interagency Bolt Action Team
ICCOPR	Interagency Committee on Oil Pollution Research
IX	Ion exchange
JAO	Joint Administrative Operations
JFSP	Joint Fire Science Program
LBNL	Lawrence Berkeley National Laboratory
LMRP	Lower marine riser package
MDTI	Mine Drainage Technology Initiative
NAAMLP	National Association of Abandoned Mine Land Programs
NAMC	National Aquatic Monitoring Center
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCPTT	National Center for Preservation Technology and Training
NCTC	National Conservation Training Center
NGO	Non-governmental organization
NMMR	National Mine Map Repository
NOAA	National Oceanic and Atmospheric Administration
NOFO	Notice of Funding Opportunity
NPS	National Park Service
NTTP	National Technical Training Program
NTTT	National Technology Transfer Team
OCS	Outer Continental Shelf
OMB	Office of Management and Budget
OORP	Office of Offshore Regulatory Programs
OPA	Office of Policy and Analysis (U.S. Geological Survey)
OPA90	Oil Pollution Act of 1990
ORTA	Office of Research and Technology Applications
OSMRE	Office of Surface Mining Reclamation and Enforcement
OSPD	Oil Spill Preparedness Branch
OSRO	Oil Spill Response Organization
OSRR	Oil Spill Response Research
PCT	Patent Cooperation Treaty
PPA	Office of Policy Analysis (U.S. Department of the Interior)
R&D	Research and Development
RODEO	Real-Time Opportunity for Development Environmental Observations
ROV	Remote operated vehicle
S&T	Science and Technology
SDE	Spatial Database Engine

SMCRA	Surface Mining Control and Reclamation Act of 1977
SME	Subject matter expert
TAA	Technical Assistance Agreement
TCEQ	Texas Commission on Environmental Quality
TEAMER	Testing and Expertise for Marine Energy
TIPS	Technical Innovation and Professional Services
TOST	Testing of Oil Spill Response Technology
UAS	Uncrewed aerial (or aircraft) services
USC	United States Code
USCG	U.S. Coast Guard
USDA FS	U.S. Department of Agriculture Forest Service
USGS	U.S. Geological Survey
USWTDB	U.S. Wind Turbine Database