BUDGET JUSTIFICATIONS

The United States Department of the Interior

and Performance Information
Fiscal Year 2016

U.S. GEOLOGICAL SURVEY

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U.S. GEOLOGICAL SURVEY
FY 2016 BUDGET JUSTIFICATION

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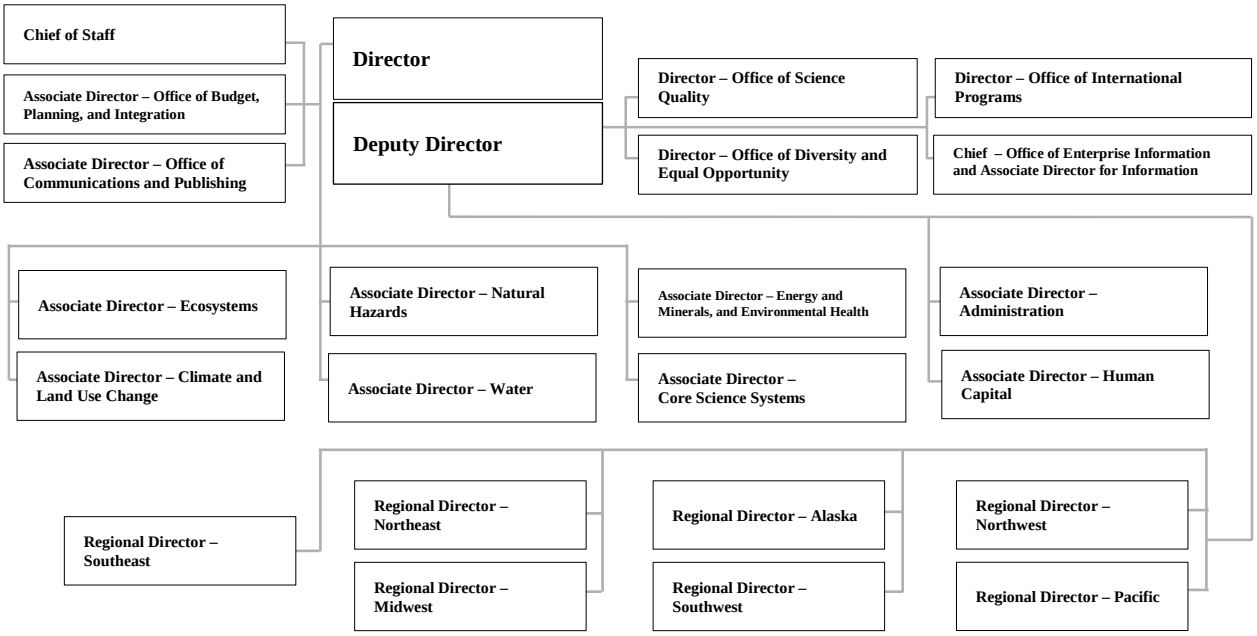
U.S. Geological Survey



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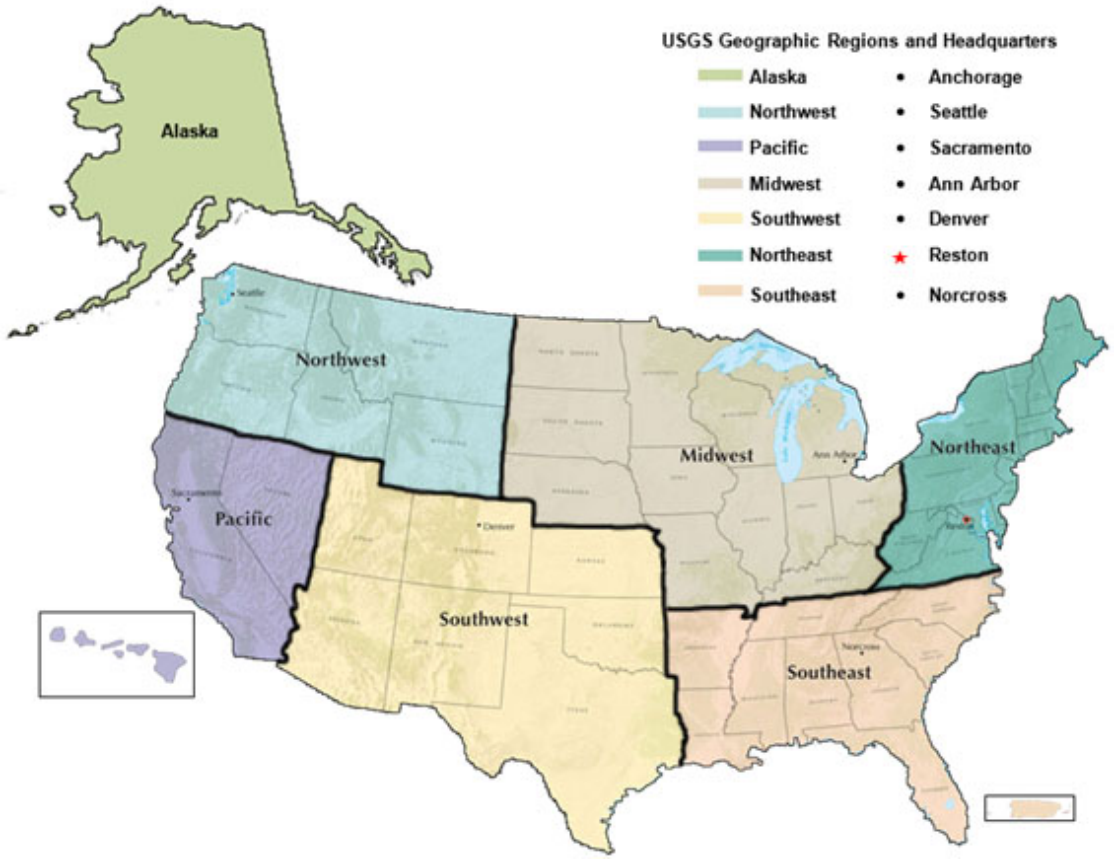


Alphabetical List of Acronyms

AAAS	American Association for the Advancement of Science
AAPG	American Association of Petroleum Geologists
ABC	Activity-Based Costing
ABC/M	Activity-Based Costing/Management
ABP	Asset Business Plan
ACCCNRS	Advisory Committee on Climate Change and Natural Resources Science
ACES	Achieving Cost Efficiencies for Science
ACI	American Competitive Initiative
ACP	Arctic Coastal Plain
ACWI	Advisory Committee on Water Information
ADA	Americans with Disabilities Act
AEI	Administration and Enterprise Information
AFS	American Fisheries Society
AFWA	U.S. Air Force Weather Agency
AMD	Aviation Management Directorate
AMP	Asset Management Plan
AMWG	Adaptive Management Work Group
ANS	Alaska North Slope
ANS	Aquatic Nuisance Species (Ecosystems)
ANSS	Advanced National Seismic System
ANWR	Arctic National Wildlife Refuge
APHIS	Department of Agriculture Animal and Plant Health Inspection Service
API	Asset Priority Index
AR	Accounts Receivable
AR5	5th Assessment Report
ARMI	Amphibian Research and Monitoring Initiative
ARRA	American Recovery and Reinvestment Act
ASC	Alaska Science Center
ASIWPCA	Association of State and Interstate Water Pollution Control Administrators
AVHRR	Advanced Very High Resolution Radiometer
AVO	Alaska Volcano Observatory
AWiFS	Advanced Wide Field Sensor
BASIS+	Budget and Science Information System
BBL	Bird Banding Laboratory
BBS	Bird Breeding Survey
BEN	Balkan Endemic Nephropathy
BT	Budget Team
BGN	Board of Geographic Names
BIA	Bureau of Indian Affairs
BIMD	Biological Information Management and Delivery
BIP	Biological Informatics Program (Equivalent to BMID)
BIS	Commerce - Bureau of Industry and Security
BLM	Bureau of Land Management
BLT	Business Leaders Team
BMPs	Best Management Practices
BNP	Biscayne National Park
BOR	Bureau of Reclamation
BPA	Blank Purchase Agreement

BPC	Bureau Program Council
BPI	USGS Office of Budget, Planning, and Integration
BPXA	BP Exploration (Alaska)
BSR	Business Strategy Review
CA	Condition Assessment
CAC	Civil Applications Committee
CALFED	California Federal (Bay-Delta Authority program)
CAP	Cooperative Agreements Program
CARA	Circum-Arctic Resource Appraisal
C&A	Certification and Accreditation
CC	Cost Center
CBERS	China/Brazil Earth Resources Satellite
CBLCM	Chesapeake Bay Land Cover Management
CBM	Coal bed Methane
CBP	Chesapeake Bay Program
CCI	Collaborative Communications Infrastructure
CCOAT	Coast Chesapeake Online Assessment Tool
CCSP	U.S. Climate Change Science Program
CDC	Centers for Disease Control and Prevention
CDR	Critical Design Review (Climate and Land Use)
CDR	Climate Data Record (Climate and Land Use)
CDI	Council for Data Integration
CEN	Climate Effects Network
CENR	Committee on Environment and Natural Resources
CEAP	Conservation Effects Assessment Project
CEGIS	Center of Excellence for Geographic Information Science
CEOS	Committee on Earth Observation Satellites
CEQ/NSTC	Council on Environmental Quality/National Science and Technology Council
CERC	Columbia Environmental Research Center
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERP	Comprehensive Everglades Restoration Plan
CESU	Cooperative Ecosystems Study Unit
CFO	Chief Financial Officer
CIO	Chief Information Officer
CISN	California Integrated Seismic Network
CITES	Conventional on International Trade in Endangered Species
CLU	Climate and Land Use Change
CMG	Coastal and Marine Geology
CMGP	Coastal and Marine Geology Program
CMSP	Coastal and Marine Spatial Planning
CNS	Central portion of the North Slope
CO_2	Carbon Dioxide
COAST	Chesapeake Online Adaptive Support Toolkit
CoML	U.S. National Committee for the Census of Marine Life
CORE	Committee on Resource Evaluation
CPIC	Capital Planning and Investment Control
CR	Central Region
CRADA	Cooperative Research and Development Agreement
CRSSP	Commercial Remote Sensing Space Policy
CRTF	Coral Reef Task Force

CRU	Cooperative Research Units
CRUISE	Columbia River USGS Integrated Science Explorer
CRV	Current Replacement Value
CRWA	Charles River Watershed Association
CSC	Climate Science Center
CSI	Core Science Informatics
CSIP	Cost Savings and Innovation Plan
CSIRC	Computer Security Incident Response Capability
CSMP	California Seafloor Mapping Program
CSRS	Civil Service Retirement System
CSS	Core Science Systems
CTBTO	Comprehensive Test Ban Treaty Organization
CUES	Comprehensive Urban Ecosystems Studies
CUSEC	Central United States Earthquake Consortium
CVJV	Central Habitat Joint Venture
CVO	Cascades Volcano Observatory
CWD	Chronic Wasting Disease
CWP	Cooperative Water Program
CWS	Canadian Wildlife Service
DCIA	Debt Collection Improvement Act
DEM	Digital Elevation Model
DEP	[State] Department of Environmental Protection
DEQ	[State] Department of Environmental Quality
DFRs	Departmental Functional Reviews
DGH	Indian Directorate General of Hydrocarbons
DHS	Department of Homeland Security
DiGIR	Distributed Generic Information Retrieval
DMC	Data Management Center
DMC	Disaster Monitoring Constellation
DMCI	Deferred Maintenance and Capital Improvements
DNR	Department of Natural Resources
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOGAMI	Oregon Department of Geology and Mineral Industries
DPAS	Data Processing and Archiving
DRAGON	Delta Research and Global Observation Network
DROT	Drift River Oil Terminal
DRTO	Dry Tortugas National Park
DWH	Deepwater Horizon
DSS	Decision Support System
EA	Enterprise Architecture
EAD	Enterprise Active Directory
EAL	Energy Analytical Laboratory
ECMs	Energy Conservation Measures
ECO	Energy Conserving Opportunities
ECS	[U.S.] Extended Continental Shelf
ECV	Essential Climate Variable
EDCs	Endocrine Disrupting Chemicals
EDEN	Everglades Depth Estimation Network
EDMAP	Education Mapping Program (in National Cooperative Geologic Mapping Program)

EDRR	Early Detection, Rapid Assessment and Response
EEOC	Equal Employment Opportunity Commission
EFT	Electronic Funds Transfer
EGIM	Enterprise Geographic Information Management
EGS	Enhanced Geothermal Systems
EHP	Earthquake Hazards Program (Hazards Program)
EHP	Enterprise Hosting Platform (AEI)
EI	Enterprise Information
EIR	Enterprise Information Resources
EISA	Energy Independence and Security Act of 2007
EIS&T	Enterprise Information Security and Technology
ELA	Enterprise License Agreement
ELT	Executive Leadership Team
EMS	Environmental Management System
E.O.	Executive Order
EOL	Encyclopedia of Life
EOP	Executive Office of the President
EOR	Enhanced Oil/Gas Recovery
EPA	U.S. Environmental Protection Agency
EPCA	Energy Policy and Conservation Act of 2000
EPM	Ecosystem Portfolio Model
ER	Eastern Region
ERA	F-Risk Assessment
ERAS	eRemote Access Services
EROS	Earth Resources Observation and Science Center
ERP	Energy Resources Program
ESD	Earth Surface Dynamics
ESI	Environmental Sensitivity Index
ESN	Enterprise Services Network
ESPC	Energy Savings Performance Contract
ESRI	Environmental Systems Research Institute
ET	Evapotranspiration
ETM+	Enhanced Thematic Mapper Plus
EVMS	Earned Value Management System
EWeb	Enterprise Web
FAA	Federal Aviation Administration
FAC	Federal Advisory Committee
FACA	Federal Advisory Committee Act
FAER	Fisheries: Aquatic and Endangered Resources
FASAB	Federal Accounting Standards Advisory Board
FBAT	Facilities Budget Allocation Team
FBMS	Financial Business Management System
FBWT	Fund Balance with Treasury
FCI	Facilities Condition Index
FEA	Federal Enterprise Architecture
FECA	Federal Employee Compensation Act
FEDMAP	Federal Lands Mapping Program (in National Cooperative Geologic Mapping Program)
FEGLI	Federal Employees Group Life Insurance
FEHB	Federal Employees Health Benefit
FEMA	Federal Emergency Management Agency

FERC	Federal Energy Regulatory Commission
FERS	Federal Employees Retirement System
FFMIA	Federal Financial Management Improvement Act of 1996
FFS	Fire and Fire Surrogate
FGDC	Federal Geographic Data Committee
FICA	Federal Insurance Contributions Act
FICMNEW	Federal Interagency Committee for the Management of Noxious and Exotic Weeds
FISC	Florida Integrated Science Center
FISMA	Federal Information Security Management Act
FMT	Field Managers Team
FMFIA	Federal Managers' Financial Integrity Act of 1982
FMMS	Facilities Maintenance Management System
FOS	Flight Operations Segment
FOT	Flight Operations Team
FRAMES	Fire Research and Management Exchange System
FRB	Federal Reserve Board
FRPC	Federal Real Property Council
FRPP	Federal Real Property Profile
FSA	Farm Service Agency
FSAM	Federal Segment Architecture Methodology
FSP	Fundamental Science Practice
FTE	Full-Time Equivalent
FWS	U.S. Fish and Wildlife Service
GAAP	Generally Accepted Accounting Principles
GAM	Geographic Analysis and Monitoring Program
GAP	Gap Analysis Program
GAO	Government Accountability Office
GBIP	Great Basin Information Project
GBIS	Global Biodiversity Information Facility
GCDAMP	Glen Canyon Dam Adaptive Management Program
GC-IMS	Global Change-Information Management System
GCP	Global Change Program
GCMRC	Grand Canyon Monitoring and Research Center
GEO	Group on Earth Observations
GEODE	GEO-Data Explorer
GeoMAC	Geospatial Multi-Agency Coordination Group
GEOMAG	Geomagnetism Program
GEOSS	Global Earth Observation System of Systems
GFDL	Geophysical Fluid Dynamics Laboratory
GFL	Global Fiducials Library
GHG	Greenhouse Gas
GIRT	Geospatial Information Response Team
GIS	Geographic Information System
GLS	Global Land Survey
GLSC	Great Lakes Science Center
GNIS	Geographic Names Information System
GOES	Geostationary Operational Environmental Satellites
GOS	Geospatial One-Stop
GPRA	Government Performance and Results Act
GRB	Green River Basin

GHG	Greenhouse Gas
GPS	Global Positioning System
GPSC	Geospatial Products and Services Contract
GSA	General Services Administration
GS-FLOW	Groundwater and Surface-water flow model
GSN	Global Seismographic Network
GWRP	Ground-Water Resources Program
HAZUS	Federal Emergency Management Agency's Earthquake Loss Estimation Program
HBN	USGS Hydrologic Benchmark Network
HDOA	Hawaii Department of Agriculture
HDR	High-Data Rate Radio
HEDDS	Highly Pathogenic Avian Influenza Early Detection Data System
HDDS	Hazards Data Distribution System
HHS	Department of Health and Human Services
HIF	Hydrologic Instrumentation Facility
HLI	Healthy Lands Initiative
HNA	Hydrologic Networks and Analysis Program
HPO	High Performing Organization
HPPG	High Priority Performance Goal
HR	Human Resources
HR&D	Hydrologic Research and Development Program
HRS	Helibourne electromagnetic Surveys
HSPD -12	Homeland Security Presidential Directive 12
HUB	Historically Underutilized Business
HUD	US Department of Housing and Urban Development
HVO	Hawaii Volcano Observatory
HWATT	Hemlock Woolly Adelgid Action Team
I&M	Inventory and Monitoring – NPS
IAGA	International Association of Geomagnetism and Aeronomy
ICAO	International Civil Authorization Organization
ICL	International Consortium on Landslides
ICRP	Internal Control Review Plan
ICWP	Interstate Council on Water Policy
IDWR	Idaho Department of Water Resources
IEAM	Integrated Environmental Assessment and Management
IGPP	Institute for Geophysics and Planetary Physics
IIE	Integrated Information Environment
ILM	Integrated Landscape Monitoring
IOOS	Integrated Ocean and coastal Observing System
IP	Investment Plan
IPCC	Intergovernmental Panel on Climate Change
IPDS	Information Product Data System
IRB	Investment Review Board
IRIS	Incorporated Research Institutions for Seismology
IRS	Indian Remote Sensing Satellite
InSAR	Interferometric Synthetic Aperture Radar
ISO	International Organization for Standardization
ISSP	Information Security Strategic Plan
IT	Information Technology
ITAP	Invasive Terrestrial Animals and Plants

ITILOB	Information Technology Infrastructure Line of Business
ITIS	Integrated Taxonomic Information System
ITSOT	IT Security Operations Team
ITSSC	IT Security Steering Committee
ITT	Information Technology Transformation
IUCN	International Union for the Conservation of Nature
IUCN	International Union of Conservation Nations
JFA	Joint Funding Agreement
JV	Joint Venture Partnerships
KSF	Thousand Square Feet
LAS	Local Action Strategy
LCAT	Land Cover Analysis Tool
LCC	Landscape Conservation Cooperatives
LCS	Land Change Science Program
LDCM	Landsat Data Continuity Mission
LDGST	Landsat Data GAP Study Team
LEAG	Long-term Estuary Assessment Group
LHP	Landslide Hazards Program
LiDAR	Light Detecting and Ranging
LIFE	NBII Library of Images from the Environment
LIMA	Landsat Image Mosaic of Antarctica
LMV	Lower Mississippi Valley
LMVJV	Lower Mississippi Valley Joint Venture Office
LOA	Level of Authentication
LRS	Land Remote Sensing
LSC	Leetown Science Center
LST	Landsat Science Team
LTRMP	Long-Term Resource Monitoring Program
LTWG	Landsat Technical Working Group
LUPM	Land Use Portfolio Model
MARCO	Mid-Atlantic Research Consortium for Oceanography
MBTU	Million British thermal units
MD	Management Directive
MEO	Most Effective Organization
METRIC	Mapping EvapoTranspiration with high Resolution and Internalized Calibration
MHDP	Multi-Hazards Demonstration Project
MMS	Minerals Management Service
MOA	Memorandum of Agreement
MOC	Mission Operations Center
MODIS	Moderate Resolution Imaging Spectroradiometer
MODFLOW	Modular Ground-Water Flow Model
MOU	Memorandum of Understanding
MRBI	Mississippi River Basin Healthy Watersheds Initiative
MRDS	Mineral Resources Data System
MRERP	Mineral Resources External Research Program
MRLC	Multi-Resolution Land Characteristics Consortium
MRP	Mineral Resources Program
MSCP	Multi-Species Conservation Program
MSH	Mount St. Helens
MSS	Multi Spectral Scanner

MTBE	Methyl Tert-Butyl Ether
MTBS	Monitoring Trends in Burn Severity
MUSIC	MIT-USGS Science Impact Collaborative
MW	Megawatt
MWE	Megawatt electric
NABCI	North American Bird Conservation Initiative
NACO	National Association of Counties
NADP	National Atmospheric Deposition Program
NAGT	National Association of Geoscience Teachers
NANPCA	Non-indigenous Aquatic Nuisance Prevention and Control Act
NARA	National Archives and Records Administration
NAS	National Academy of Sciences (Core Science)
NAS	USGS National Non-indigenous Aquatic Species Database (Ecosystems)
NASA	National Aeronautics and Space Administration
NASQAN	National Stream Quality Accounting Network
NatWeb	National Web Server System
NAWQA	National Water-Quality Assessment
NBC	Department of the Interior – National Business Center
NBII	National Biological Information Infrastructure
NCA	National Climate Assessment
NCAR	National Center for Atmospheric Research
NCAP	National Civil Applications Program
NCCWSC	National Climate Change and Wildlife Science Center
NCDE	Northern Continental Divide Ecosystem
NCEP/NOAA	National Centers for Environmental Prediction
NCGMP	National Cooperative Geologic Mapping Program
NCIA	National Competitiveness Investment Act
NCPP	USGS National Coastal Program Plan
NCRDS	National Coal Resources Data System
NDMC	National Drought Mitigation Center
NDOP	National Digital Orthoimagery Program
NED	National Elevation Dataset
NEHRP	National Earthquake Hazards Reduction Program
NEIC	National Earthquake Information Center
NEON	National Ecological Observatory Network
NEPA	National Environmental Policy Act
NEST	National Environmental Status and Trends
NETL	National Energy Technology Laboratory
NFHAP	National Fish Habitat Action Plan
NGA	National Geospatial-Intelligence Agency
NGAC	National Geospatial Advisory Committee
NGGDPP	National Geological and Geophysical Data Preservation Program
NGIC	National Geomagnetic Information Center
NGMA	National Geologic Mapping Act
NGMDP	National Geologic Map Database Project
NGO	Nongovernmental organization
NGP	National Geospatial Program
NGWMN	National Ground Water Monitoring Network
NHD	National Hydrography Dataset
NHWC	National Hydrologic Warning Council

NIEHS	National Institute of Environmental Health Sciences
NIFC	National Interagency Fire Center
NIH	National Institute of Health
NISC	National Invasive Species Council
NIISS	National Institute for Invasive Species Science
NISMP	National Invasive Species Management Plan
NIST	National Institute of Standards and Technology
NIWR	National Institutes for Water Resources
NLC	National League of Cities
NLCD	National Land Cover Database
NLlC	National Landslide Information Center
NLIP	National Land Imaging Program
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Aerospace Defense Command
NORTHCOM	U.S. Northern Command
NOSC	National Operations and Security Center
NPN	National Phenology Network
NPRA	National Petroleum Reserve Alaska
NPS	National Park Service
NRDA	Natural Resource Damage Assessment
NRIS	Natural Resource Information System
NRC	National Research Council (United States National Academies)
NRC	Nuclear Regulatory Commission (United States NRC)
NRCS	Natural Resources Conservation Service
NRMP	National Resource Monitoring Partnership
NROC	Northeast Regional Ocean Council
NRP	National Research Program (research organization in USGS Water Resources)
NRPP	National Resource Preservation Program
NSDI	National Spatial Data Infrastructure
NSF	National Science Foundation
NSGIC	National States Geographic Information Council
NSIP	National Streamflow Information Program
NSLRSDA	National Satellite Land Remote Sensing Data Archive
NSMP	National Strong Motion Program
NSPD	National Space Policy
NSTC	National Science and Technology Council
NSVRC	Northern Shenandoah Valley Regional Commission
NTN	National Trends Network
NVCS	National Vegetation Classification Standard
NVEWS	National Volcano Early Warning System
NWAVU	National Water Availability and Use Assessment
NWHC	National Wildlife Health Center
NWIS	National Water Information System
NWQL	National Water Quality Laboratory
NWQMN	National Water Quality Monitoring Network
NWRC	National Wetlands Research Center
NWS	National Weather Service
O&M	Operations and Maintenance
OAEI	Office of Administration and Enterprise Information
OAFM	USGS Office of Accounting and Financial Management

OAG	USGS Office of Acquisition and Grants
OAP	Ocean Action Plan
OBIS	Ocean Biogeographic Information System
OBIS	USGS Office of Business Information Systems, (AEI)
OCAP	USGS Office of Communication and Publications
OED	Office of Employee Development
OEPC	Office of Environmental Policy and Compliance
OES	Office of Emergency Services
OFDA	Office of Foreign Disaster Assistance
OFEE	Office of the Federal Environmental Executive
OFR	Open-File Report
OGC	Open Geospatial Consortium
OHC	USGS Office of Human Capital
OIA	Office of Insular Affairs
OICR	USGS Office of Internal Control and Reporting
OIG	Office of the Inspector General
OGDB	Organic Geochemistry Database
OLI	Operational Land Imager
OMB	Office of Management and Budget
OMS	USGS Office of Management Services
OPA	USGS Office of Policy and Analysis
OPM	Office of Personnel Management
ORPP	Ocean Research Priority Plan
ORPPIS	Ocean Research and Priorities Plan and Implementation Strategy
OSHA	Occupational Safety and Health Administration
OSM	Office of Surface Mining
OSQI	Office of Science Quality and Integrity
OSTP	Office of Science and Technology Policy
OWRS	Office of Western Regional Services
PAGER	Prompt Assessment of Global Earthquakes for Response
PBO	Plate Boundary Observatory
PBX	Private Branch Exchange
PCR	Polymerase Chain Reaction
PDA	Personal Digital Assistant
PDF	Portable Document Format
PDR	Preliminary Design Review
PES	Priority Ecosystem Science
PFM	(Department) Office of Financial Management
PI	Principal Investigator
PII	Personally Identifiable Information
PIP	Performance Improvement Plan
PIP	Program Improvement Plan
PMO	Project Management Office
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
POA&M	Plan of Action and Milestone
PP&E	Property, Plant, and Equipment
PRB	Powder River Basin
PSNER	Puget Sound Near Shore Ecosystem Restoration
PSS	Perimeter Security Standard
PTWC	Pacific Tsunami Warning Center

PWRC	Patuxent Wildlife Research Center
QOL	Quality of Life
R&D	Research and Development
RASA	Regional Aquifer-System Analysis
RCM	Regional Climate Models
RCOOS	Regional Coastal Ocean Observing Systems
REE	Rare Earth Elements
REMS	River Ecosystem and Modeling Science
RFP	Request for Proposal
RGIO	Regional Geospatial Information Office®
RIF	Reduction in Force
RIM	River Input Monitoring Program
RISA	Regional Integrated Science and Assessments – NOAA
RPM	Real Property Management System
RSAC	Remote Sensing Application Center
RSSI	Required Supplementary Stewardship Information
RTS	Reports Tracking System (Water Resources)
R/V	Research Vessel
RWRPC	Regional Water Resources Policy Committee
S&T	USGS Status and Trends Program
SAC	Stakeholder advisory Committee (Climate and Land use)
SAC	USGS Science Advisory Council
SAFOD	San Andreas Fault Observatory at Depth
SAFRR	Science Application for Risk Reduction
SAIN	Southern Appalachian Information Node
SAP	Synthesis and Assessment Product
SAR	Synthetic Aperture Radar
SAUS	Storage Assessment Units
SBFD	San Francisco Bay and freshwater delta
SBSP	South Bay Salt Pond Restoration Project
SCEC	Southern California Earthquake Center
SCR	System Concept Review
SDI	Spatial Data Infrastructures
SDR	Subcommittee for Disaster Reductions
SDRT	Supervisory Development Review Team
SES	Senior Executive Service
SETAC	Society of Environmental Toxicology and Chemistry
SFBD	San Francisco Bay Delta
SFMP	Strategic Facilities Master Plan
SFWMD	South Florida Water Management District
SHC	Strategic Habitat Conservation
SLC	Scan Line Corrector
SGL	Standard General Ledger
SIR	Surveys, Investigations, and Research
SOGW	Subcommittee of Ground Water
SoIVES	Social Values for Ecosystem Services
SOW	Statement of Work
SPARROW	Spatially Referenced Regressions on Watershed Attributes
SPN	Scientific Publishing Network
SPOC	Security Point of Contact

SPOT	Satellite Pour L'Observation de la Terre
SPRESO	South Pole Remote Earth Science Observatory
SRR	Systems Requirement Review
SRTM	Shuttle Radar Topographic Mission
SSRIs	Selective Seronin Reuptake Inhibitors
STATEMAP	State Mapping Program (in Cooperative Geologic Mapping Program)
STEM	Science, Technology, Engineering and Mathematics
STIG	Security Technical Implementation Guides
SWPC	Space Weather Prediction Center
TAA	Technical Assistance Agreements
TANC	Transport of Anthropogenic and Natural Contaminants
TCOM	Tahoe Constrained Optimization Model
TDWG	Biodiversity Information Standards
TIC	Trusted Internet Connection
TIRS	Thermal Infrared Sensor
TM	Thematic Mapper
TMDL	Total Maximum Daily Loads (Clean Water Act requirement)
TRIGRS	Transient Rainfall Infiltration and Grid-Based Regional Slope-Stability Analysis
TRIP	The Road Indicator Project
TROR	Treasury Report on Receivables
TRPA	Tahoe Regional Planning Agency
TSP	Thrift Savings Plan
UAS	Unmanned Aircraft Systems
UHM	University of Hawaii-Manoa
UIC	Underground Injection Control
URISA	Urban and Regional Information System Association
U.S.	United States
USACE	U.S. Army Corps of Engineers
USAID	U.S. Agency for International Development
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
USDOE	U.S. Department of Energy
USFS	U.S. Forest Service
USGCRP	U.S. Global Change Research Program
USGEO	U.S. Group on Earth Observations
USGS	U.S. Geological Survey
UMESC	Upper Midwest Environmental Services Center
USNG	United States Nation Grid
VANS	Volcano Activity Notices
VBNS	Very Broadband Network Services
VCP	Vegetation Characterization Program
VDAP	Volcano Disaster Assistance Program
Veg	Vegetation Characterization
VegDRI	Vegetation Drought Response Index
VHP	Volcano Hazards Program
VHSV	Viral Hemorrhagic Septicemia Virus
VOIP	Voice over IP Systems
VONA	Volcano Observatory Notifications for Aviation
VSIP/VERA	Voluntary Separation Incentive Payment/Voluntary Early Retirement Authority
VTC	Video Teleconferencing

WAN	Wide Area Network
WCCI	Wyoming Cooperative Conservation Initiative
WCF	Working Capital Fund
WCMC	UNEP-World Conservation Monitoring Center
WERC	Western Ecological Research Center
WFRC	Western Fisheries Research Center
WLAN	Wide Local Area Network
WLCI	Wyoming Landscape Conservation Initiative
WNS	White-Nose Syndrome
WNV	West Nile Virus
WPA	World Petroleum Assessment 2000
WR	Western Region
WRD	Water Resources discipline (formerly Water Resources Division)
WRIR	Water Resources Investigation Report
WRRA	Water Resources Research Act
WRRIs	[State] Water Resources Research Institutes
WSC	[USGS State] Water Science Center
WSWC	Western States Water Council
WTER	Wildlife: Terrestrial and Endangered Resources
WUI	Wildland-Urban Interface
YMP	Yucca Mountain Program
YVO	Yellowstone Volcano Observatory

Executive Summary

Executive Summary

Budget Authority	2014 Actual	2015 Enacted	2016 Request
Current	1,032,000	1,045,000	0
Current Mandatory	0	0	0
Total Current	***1,032,000***	***1,045,000***	***0***
Permanent	2,318	36,978	1,104
Total Current and Permanent	**1,034,318**	**1,081,978**	**1,104**
FTEs	4,982	4,935	5,142

FTE	2014 Actual	2015 Enacted	2016 Request
Direct	4,982	4,935	5,142
Reimbursable	2,687	2,687	2,687
Working Capital Fund	229	229	229
Allocation Account	71	71	71
Contributed	7	7	7
Total	**7,976**	**7,929**	**8,136**

Introduction

This year, the U.S. Geological Survey (USGS) celebrates 136 years of providing the Nation with reliable scientific information used to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, ecosystem, energy and mineral resources; and enhance and protect quality of life. The USGS plays a key role in the President's ongoing commitment to scientific discovery and innovation to support decisionmaking, innovation, a robust economy, and critical societal needs.

The USGS is committed to engaging the next generation of scientists and investing in priorities that ensure that the USGS is at the leading edge of the Earth sciences and able to advance the stewardship of natural resources. For example, the Department of the Interior (Interior) is responding to climate change with new approaches that include managing public lands to increase capture of carbon emissions, largely based on the research and information provided by the USGS. Interior, States and communities also need new strategies to respond to historically significant droughts. USGS science and information is a starting point for developing solutions that allow for the management of healthy watersheds that provide clean, reliable water supplies.

The 2016 USGS budget request is $1,194.8 million, which is $149.8 million or 14.3 percent above the 2015 Enacted Budget. The 2016 budget reflects the Administration's commitment to invest in research and development to support sustainable economic growth, manage competing demands on environmental resources, address global climate change and move toward a clean energy future, and ensure the security and well-being of the Nation. Sustainable stewardship of natural resources requires strong investments in research and development in the natural sciences to strengthen the scientific basis for decisionmaking. The USGS budget invests in critical research, development, and monitoring infrastructure, to support natural resource decisionmaking, particularly in areas that support Interior's resource management

mission and trust responsibilities, and to provide world-class science to Federal, State, tribal, local, and international partners who rely on USGS data, information, and tools.

USGS Organic Act

43 U.S.C. 31 et seq. Organic Act of March 3, 1879, as amended, establishes the United States Geological Survey. Provides, among other matters, that the USGS is directed to classify the public lands and examine the geologic structure, mineral resources, and products within and outside the national domain. Establishes the Office of the Director of the United States Geological Survey under the Department of the Interior. The Director is appointed by the President with the advice and consent of the Senate.

The 2016 USGS budget makes strategic science investments to advance national priorities in support of: land management; sustainable energy and mineral development; responding to natural hazards; protection and restoration of important landscapes and ecosystems; sustainable water management; understanding and responding to climate change; and the science infrastructure and services that are the foundation of delivering that science to communities and decisionmakers.

Budget Highlights

The USGS proposes changes of $137.2 million from the 2015 Enacted Budget to advance priority directions outlined in the USGS Science Strategy and the 2015 President's Budget Request, and in support of the Secretarial Initiatives: Powering Our Future, Watersheds and Water Supplies, Landscape-Level Understanding, and Engaging the Next Generation.

Budget Change Summary ($ in Thousands)	
2015 Enacted	**$1,045,000**
Program Change	137,231
Fixed Costs	8,969
Seasonal Federal Health Benefits	3,582
2016 Request	**$1,194,782**

2016 Budget Request Scenarios						
($ in Thousands)						
Budget Authority			**2016**			
Surveys, Investigations, and Research	**2014 Enacted**	**2015 Enacted Budget**	**Fixed Costs and Related Changes ***	**2016 Program Changes**	**2016 Internal Transfers**	**2016 Budget Requet**
Ecosystems	152,811	157,041	3,907	13,160	2,191	176,299
Climate and Land Use Change	131,975	135,975	880	54,973	0	191,828
Energy, Minerals, and Environmental Health	91,515	92,271	1,434	9,597	0	103,302
Natural Hazards	128,486	135,186	1,766	9,227	174	146,353
Water Resources	207,281	211,267	3,392	10,584	(2,365)	222,878
Core Science Systems	108,807	107,228	1,180	18,559	0	126,967
Science Support	110,704	105,611	2,400	4,817	0	112,828
Facilities	100,421	100,421	(2,408)	16,314	0	114,327
Grand Total	**1,032,000**	**1,045,000**	**12,551**	**137,231**	**0**	**1,194,782**

* Includes Seasonal Federal Health Benefit

Recent Accomplishments that Provide a Strong Foundation for the 2016 Budget

In the 2016 President's budget request, the USGS builds on research and development (R&D) priorities funded in 2014 and 2015. The 2016 request recognizes the role USGS science plays in addressing Interior's mission and key Administration priorities. USGS accomplishments in 2014 demonstrate that maintaining support for these directions in 2015 and 2016 is critical to communities across the Nation.

Climate and Land Use Change – The USGS is conducting research to improve the understanding of regional impacts of climate and land use change, which is critical to supporting communities and resource managers as they make important decisions. This research contributes to efforts that are jointly supported by the Climate Research & Development (R&D) Program and the Department of the Interior Climate Science Centers (CSCs). Emerging science needs include the identification of long-term patterns, causes, and impacts of drought; improving estimates of potential magnitudes and ranges of sea-level rise; the response of coastal ecosystems to changing sea level; and the application of process-based research to resource management issues. The USGS will provide important information needed to evaluate and forecast the vulnerability of critical habitats to different climate and land-use change scenarios. The partnership between the Climate R&D Program and the CSCs provides a strong mechanism to infuse long-term and fundamental research into actionable science for decisionmakers' pressing needs.

Disaster Response – Every year the United States faces natural disasters that pose threats through loss of life and property, degradation of human health and the environment, and threats to national security and economic vitality. The Nation's emergency managers and public officials use USGS science to inform them of the risks hazards pose to human and natural systems, how to reduce losses, and improve response in disasters. Major events in which USGS science has been critical to informing emergency response, include the landslides in Washington and Colorado, Midwest flooding, Hurricane Sandy, Japan's Great Tohoku earthquake and Pacific-wide tsunami, volcanic eruptions in Alaska, and the California earthquake near Napa. Faced with rising expectations for rapid, robust information in response to these events, the USGS is using funding increases to strengthen its capabilities both before and after disasters strike. The

USGS proposes to begin to implement a limited public earthquake early warning system in southern California in 2015 (to be completed by 2018), to improve monitoring at the Nation's very high- to high-threat volcanoes, and expand the capability of the USGS to respond to landslide crises and geomagnetic storms. The USGS will also build upon datasets, regional geologic studies, and models of coastal change and vulnerability that were developed and enhanced with supplemental funding in the aftermath of Hurricane Sandy to improve forecasts and assessments of the vulnerability of coastal lands and resources to future extreme storms and sea-level rise, which has the potential to have significant impacts on society, infrastructure, and coastal habitats that serve as buffers to storm surges and severe weather events, particularly due to population density along the Nation's coastline.

Water Challenges and Drought – The Nation faces an increasing set of water resource challenges, and the USGS is providing the science to help water managers understand and address competing demands for water through the WaterSMART initiative. In 2014, the USGS continued to monitor and conduct research to generate more-precise estimates of water availability and use for meeting current and future human and ecological requirements. These research and monitoring activities will be enhanced and expanded in 2016. Work in 2015 and 2016 continues a focus on drought and resilient water management. California has been experiencing one of its most severe droughts in over a century, and 2013 was the driest calendar year in the State's 119-year recorded history. In 2015, the Water Resources Mission Area released an interactive California Drought visualization Web site (*http://cida.usgs.gov/ca_drought/*) aimed at providing the public with atlas-like, statewide coverage of the drought and a timeline of its impacts on water resources. The USGS developed the interactive Web site as part of the Federal government's Open Water Data Initiative, which promotes making valuable water data more accessible and in a more user friendly format. The drought visualization page features high-tech graphics that illustrate the effect of drought on regional reservoir storage from 2011-2014.

USGS science and technical support have been crucial to State and Federal water-resource agencies and other partners as they grapple with numerous near-term drought management decisions in California. USGS scientists have briefed agency leaders on emergent science activities including the outmigration of juvenile Chinook salmon in the Sacramento River, which can affect decisions regarding water delivery patterns in the Sacramento-San Joaquin Delta. USGS researchers also provided information to the Bureau of Reclamation on land subsidence in the Central Valley of California related to increased groundwater pumping and its impacts on water delivery infrastructure. The Earth Resources and Observation and Science (EROS) Center developed and distributed a graphic comparison of Landsat images depicting the impact of the current drought on snowpack in the Sierra Nevada. The USGS provided partners with data on Western Sierra soil moisture estimates and San Francisco Bay salinity patterns. To increase awareness of the drought and its ramifications, the USGS hosted a California Drought Press Roundtable, in which reporters talked directly to an array of USGS experts and generated numerous media reports.

The USGS initiated and conducted new studies on key drought-related issues, and partnered with agencies contributing to the National Integrated Drought Information System (NIDIS) to develop and demonstrate a variety of early warning information resources and strategies. Researchers initiated a study to better characterize land subsidence in the San Joaquin Valley and determine land-surface elevation changes since 2003. The USGS installed new instrumentation to collect baseline water quality data in

Sacramento-San Joaquin Delta sloughs, as part of possible salinity control. Researchers initiated studies on how the drought might affect management of waterfowl habitat in the California Central Valley, and monitored the effect of the drought on endangered species such as the desert tortoise.

Arctic Research – The 2016 request allows the USGS to build programs and stay on the leading edge of Arctic science, which is critical not only to supporting communities in Alaska, but to national and international priorities for the United States as an Arctic Nation, such as those articulated in the President's National Strategy for the Arctic Region. Some examples of ongoing work range from wildlife and environmental health issues to research on hydrologic, biogeochemical, and ecosystem effects of permafrost thawing. The Arctic is warming faster than any other region on Earth, and changes to the cryosphere (the frozen water part of the Earth system) are among the most significant consequences of this change. In areas such as Alaska, observations show that the vast majority of glaciers are losing mass at an astounding rate, while rapid permafrost loss can be seen from coastal areas to inland forests and tundra. In turn, shrinking permafrost and glaciers have brought a host of impacts to the broader physical environment, such as the formation of thermokarst lakes (land-surface configuration that results from the melting of ground ice in a region that creates the lake, sinkhole, tunnel, etc.), altered streamflow paths and regimes, disruption of ocean currents, and sea-level rise. Less understood is how glacier and permafrost change alters downstream ecosystems and the resources they provide. In 2016, the USGS proposes to take a whole-system approach to study the many dimensions—physical, biological, social and economic—of permafrost and glacier loss. This approach will be driven by the near-term needs of stakeholders and will build cross-disciplinary teams of scientists using a blend of measurements, conceptual modeling, and process modeling within a collaborative framework as a means to clarify the linkages between climate, glaciers and human impacts. This effort will build on a rich legacy of Federal science in the Arctic, while also capitalizing on capacity from the broader research community. Completion of this project, for instance, will allow managers in the Arctic to understand the potential climate impacts to glaciers and determine potential changes in production of salmon and migratory waterfowl, wildfire regimes across Alaska, and changes in permafrost. This information will help support State, tribal, and local entities and communities, as well as Federal and international partners, in planning and making decisions.

Geospatial Data Coordination and Mapping – The 2016 budget request includes funding for several efforts that will support geospatial data coordination and mapping. This includes support for the Big Earth Data Initiative, improvements to the National Hydrography Data Set, Landsat data products, Alaska Mapping, and the 3D Elevation Program (3DEP). All of these efforts in addition to other existing mapping and data activities are also strengthened by USGS leadership through the Federal Geographic Data Committee and the geospatial platform. These sources of information and tools are used as foundational information for decisions in areas such as precision agriculture, hazard detection, coastal planning, land use planning, and land and resource management. In 2015, more than 50 percent of the State of Alaska will have new imagery completed.

Science Coordination

The President's Budget continues to promote research and development, scientific investments, and monitoring to manage the country's natural resources and heritage. Continued and enhanced coordination

of science activities across Interior bureaus and other agencies is required to achieve the Department's important mission objectives. The 2016 budget facilitates this need by better supporting integrated efforts to achieve resource management outcomes. The USGS has identified several key areas for investment where coordination with other Interior bureaus will leverage results to more effectively achieve mission outcomes.

Chesapeake – Interior plays a leadership role for seven of the 10 goals in the 2014 Chesapeake Bay Agreement, which guide the restoration and conservation of the Nation's largest estuary. USGS research, which has evolved to address new ecosystem management issues, will include: (1) investigating the effects of land and climate change on freshwater fish populations and habitats; (2) identifying the sources and effects of the chemicals causing intersex conditions in fish and wildlife populations; (3) modeling the carrying capacity of wetlands near six Fish and Wildlife Service Refuges in the Bay to support Black Duck and waterfowl populations; (4) predicting land and climate change effects to inform land conservation efforts being led by the National Park Service and climate adaptation planning; and (5) monitoring and explaining water-quality response to management practices to reduce nutrient and sediment, which included a synthesis report of existing information. Selected products for 2015 include a report of climate change effects on stream temperatures, and summaries of information on occurrence of intersex conditions. In 2016, anticipated products include report on water-quality trends and improved land-change analysis of the watershed.

Alaska Mapping – The USGS is working with other Federal agencies and State partners to remap the State of Alaska during 2013-2019. A consortium of agencies, led by the USGS, will have higher resolution elevation data for 48 percent of the State by the end of 2014. Over 700 new topographic maps will be created in 2014. These updates are critical for applications that address a wide array of needs that include aviation safety, flood hazard mapping, and State, tribal, and local land use planning.

California Earthquake Early Warning – The USGS has been operating a demonstration earthquake early warning system in California, called *ShakeAlert*, since January 2012, and is now expanding to Oregon and Washington. The development effort is a collaboration among U.C. Berkeley, Caltech, the University of Washington, and the USGS.

Open Data: Big Earth Data Initiative – The USGS will continue to provide leadership to further develop the implementation plan for the Big Earth Data Initiative (BEDI). This plan outlines an approach to be followed by Interior and the bureaus most involved in collecting and managing high value Earth observations—the USGS, Fish and Wildlife Service, National Park Service, and the Bureau of Land Management. These observations include data such as streamgage data, the Biodiversity Information Serving Our Nation (BISON) data, and Ocean Biogeographic Information System-USA data. Efforts are concentrated on making Earth science data available through Data.gov and specialized collaborative portals such as Ocean.data.gov and Ecosystems.data.gov, to support decisionmakers. The USGS is integrating ecological data through the BISON platform and making data interoperable with other data systems. Efforts such as these, completed in 2014, are critical to supporting the Secretary of the Interior's goal of landscape level management and the President's Climate Action Plan.

High Value Datasets – To enhance public access to USGS data, USGS Information Services worked with the science mission areas to achieve the Administration's Open Data goals of increasing cross-agency and public access to government data. Through these collaborative relationships, the USGS has submitted more than 265,381 high-value datasets to data.gov and has been routinely ranked number one for dataset and tools views and usage in 2013.

The USGS also continued its focus on preserving science for future generations by ensuring that data from 20 scientific projects were preserved as one-of-a-kind, high-value datasets, documents, reports, maps, imagery and other information. The Records Program analog to digital preservation activity is the culmination of a six-year effort that has successfully stored and made publicly accessible data from 113 USGS projects that span more than 100 years of research in energy resource availability, water, ecosystems, climate, hazards, and geography. Now preserved and digitally accessible, these data are being made available to the science community, stakeholders, and the public for the first time, serving diverse scientific and marketplace needs today and for future generations.

National Hydrography Data Requirements and Benefits Study – Under the leadership of the USGS and the interagency National Hydrography Dataset Management Team, the National Geospatial Program (NGP) National Hydrography Data Requirements and Benefits Study was initiated in 2014 to document business uses and quantify benefits for high-resolution, consistent hydrography data. Activities underway in 2015 are to: (1) document major uses of geospatial water information by Federal, State, tribal, and local governments, water utilities and other private sector industries, not for profits, and the academic research community; (2) document benefits that will be realized from a Hydrographic Analysis Framework—not just a dataset but a system; (3) identify the data types, quality, organization, and delivery mechanisms required to achieve those benefits; and (4) develop a menu of proposed program approaches with associated costs and benefits. To gather the data, the USGS will reach out to 30 Federal agencies, all 50 States, and several major private users such as Tennessee Valley Authority, Bonneville Power Administration, the Great Lakes Commission, and others. Results of the study will build on more than 20 years of community collaboration on the National Map's National Hydrography Dataset to design the next generation of hydrography data.

National Ocean Policy (NOP) – Interior is working to harness emerging technologies and work with partners to elevate the Nation's understanding of our resources on a landscape level, including those of our coasts and oceans. The mission of the USGS requires diligent and thoughtful management of these resources that are vital to local, tribal, State and regional stakeholders. Interior uses the forum provided through the National Ocean Council to work together with other Federal agencies involved in coastal and ocean issues to reduce duplication and red tape, and ensure taxpayer dollars are used most efficiently. It also provides a useful means for agencies to coordinate with States, industry, and others on a wide range of ocean and coastal responsibilities. All ocean and coastal work supports bureau missions and statutory authorities and because actions taken often support or are consistent with the NOP Implementation Plan, it is not possible to separate work done to further the NOP Implementation Plan milestones from work done to carry out those missions.

Urban Waters – The Urban Waters Federal Partnership is a federally-sponsored program designed to reconnect economically distressed urban communities with their waterways by improving coordination

among Federal agencies and collaborating with community-led revitalization efforts to improve our Nation's urban water resources systems and to meet key needs of urban areas and urban leaders in building economies, creating jobs, revitalizing cities, and improving water quality. The Federal partnership started in 2011, and the USGS has been conducting work in: the District of Columbia (Anacostia River), Baltimore (Patapsco River), New York City (Bronx and Harlem Rivers), Denver (South Platte River), Los Angeles (Los Angeles River), New Orleans (Lake Pontchartrain), and northwest Indiana (Calumet River/Lake Michigan coast), Boston (Mystic River), New Jersey (Passaic River), Atlanta (Proctor Creek watershed), Kansas City (Middle Blue River), Grand Rapids (Grand River), Philadelphia (Delaware River watershed), Toledo (Western Lake Erie Basin), and Seattle (Puget Sound-Green-Duwamish watershed). Within the scope of the program, USGS activities in some of these locations include improving streamgage coverage; water quality sampling, monitoring, and analyses; and assessing the health of aquatic ecosystems.

New funding in 2016 would provide new streamgages or upgrade existing streamgages; enhance water quality, water quantity, and habitat monitoring; support studies to understand the use of green infrastructure to reduce the impact of stormwater runoff; and to develop modeling tools to simulate water quality, biological conditions, and to describe stream health. New multi-stressor models would provide insight on how management actions can improve water quality, flow characteristics, habitat, and biological conditions.

Fixed Costs and Health Benefits for Seasonal Employees

Fixed Costs – The fixed costs for the USGS in 2016 are $9.0 million, which include increases and decreases for the various components of fixed costs. Fixed costs for 2016 include an increase of $10.4 million for salaries and benefits, an increase of $1.01 million for the Department's Working Capital Fund, a decrease of $0.02 million for workers' compensation, an increase of $0.01 million for unemployment compensation, and a decrease of $2.5 million for rent savings. More information on the USGS contribution to the Department's Working Capital Fund, and the fixed costs calculations, are located in Section P, Sundry Exhibits. Cost saving projects have resulted in a smaller facilities footprint and reduced the USGS rent costs. More information on rented facilities, owned facilities and their operation and maintenance, and cost saving projects is located in the Facilities Section.

There is a reduction of $2.5 million in Rental Payments and Operations and Maintenance Fixed Cost based on a calculation in OMB's Exhibit 54, the document used to calculate increases or decreases in GSA rent estimates covering all changes such as lease and operating cost. The USGS shows a rent cost reduction due to aggressive efforts to reduce space at three of its largest centers and through co-locations. The calculation in OMB's Exhibit does not however include adjustments for any changes in the increasing cost for Operations and Maintenance of own facilities. These increases are mainly due to inflation creating an additional shortfall in the Rental Payments and Operations and Maintenance Subactivity.

Health Benefits for Seasonal Employees – On July 29, 2014, OPM issued a proposed rule that would expand eligibility for enrollment under the Federal Employee Health Benefits (FEHB) program to certain temporary, seasonal and intermittent employees. This regulation would make FEHB coverage available

to these newly eligible employees no later than January 2015. The Interior developed a model to estimate the number of employees who would accept the new coverage and the estimated cost to the government. The Surveys, Investigations and Research account includes $3.6 million for the 2016 program and fixed cost change associated with the estimated cost for new coverage under FEHB.

Technical Changes

Energy, Minerals, and Environmental Health – In 2016, the USGS proposes the following changes for the Energy, Minerals, and Environmental (EMEH) budget activity and the four subactivities within it. The changes are budget neutral. There would now be two subactivities under EMEH: Mineral and Energy Resources, and Environmental Health. Under the Mineral and Energy Resources subactivity, there would be two Program Elements: Mineral Resources, and Energy Resources. Under the Environmental Health subactivity, there would be two Program Elements: Contaminant Biology, and Toxic Substances Hydrology. For additional information and a crosswalk, see Section B, Technical Adjustments.

Restructuring the Water Resources Mission Area Budget – The U.S. Geological Survey (USGS) Water Science Strategy (Strategy), outlined in USGS Circular 1383-G *Observing, Understanding, Predicting, and Delivering Water Science to the Nation,* identifies water science goals and objectives that serve the Nation and address the water challenges for the future. The Strategy outlines areas where hydrologic science can make substantial contributions to the Nation and identifies opportunities for the USGS to better use its hydrologic science capabilities to address Administration priorities to ensure healthy watersheds and sustainable, secure water supplies. In doing so, the Strategy is intended to inform long-term approaches to USGS program planning, technology investment, partnership development, and workforce and human capital strategies. The choice of strategic water science-priority actions, goals and objectives is based on the guiding principles to *observe, understand, predict* and *deliver* water information that allows society to meet the water challenges of the Nation, current and future. While the Strategy does not cover all facets of USGS work in hydrology, it builds on a hierarchy of planning documents and provides a science-based response to the overarching issues of water availability and hydrologic hazards.

In order to achieve the Strategy vision, it is critical to align the mission area's budget and funding decisions with the Strategy's goals and objectives. In 2016, the USGS plans to align the Water Resources Mission Area budget structure to the Water Science Strategy by consolidating its seven existing programs into four major program areas. The Groundwater and Streamflow Information Program, primarily focuses on *Observing and Delivering*. The other three programs, National Water Quality Program; Water Availability and Use Science Program; and Water Resources Research Act primarily focus on *Understanding, Predicting, and Delivering,* although observations are a key component for this Strategy action.

For additional information and a crosswalk, see Section B, Technical Adjustments.

Program Changes

Program changes requested for 2016 cut across the following thematic priorities, which align with the USGS Science Strategy and reflects the cross-disciplinary science required to address the complex natural resources management issues that face decisionmakers and communities across the Nation. Details on the funding request for each science theme are located in the Program Change Section.

Water Science for the 21st Century ($14.5 million) – The accessibility and quality of water is an essential ingredient for healthy communities, economies, and ecosystems across the Nation. In 2016, the USGS will expand, enhance, and initiate science efforts related to the quantity and quality of water. At a time when ensuring sustainable water supplies is more important than ever, changes in the frequency and magnitude of extreme hydrologic events, such as floods and droughts, is creating uncertainty for water managers. Efforts will continue and expand under Interior's WaterSMART initiative. USGS scientists will provide land, water, and other resources managers with science, monitoring, assessments and tools to understand, address, and plan for water management needs. The primary focus will continue to be on developing a national water census, better understanding water budgets, and supporting sustainable and environmentally sound water management. Expertise across multiple disciplines enables a broader focus to provide water resource, ecosystem, land managers, and communities with the decision-support tools needed to make informed decisions.

Climate Resilience ($32.0 million) – The USGS plays an important role in conducting research, providing data on the Earth's systems, and in developing information and tools to support communities and Federal, State, tribal, local, and international partners in understanding, preparing for, and responding to the impacts of global climate change. In 2016, the USGS will expand partnerships and collaboration, translate science into practical application-ready solutions, initiate new science activities in emerging areas such as integrating long historical records into climate modeling, establish a national carbon inventory and tracking system, and building a clearinghouse of data, tools, shared applications, and best practices for use by resource managers, decisionmakers, and the public.

Energy and Minerals ($9.6 million) – Energy and mineral development are important to the economy, national security, and standard of living of the Nation. USGS science helps inform decisionmakers as they balance adequate and reliable energy and mineral supplies with the potential impacts of their development and use. In 2016, the USGS will support science to advance understanding of: the environmental and human health impacts of unconventional oil and gas resources; the impacts of wind and solar energy development on wildlife, and mitigation strategies to address those impacts; critical minerals such as rare earth minerals; and environmental impacts of uranium mining.

Landscape Understanding ($15.6 million) – Land uses are increasingly interconnected and often compete with one another on a landscape scale. Interior, other Federal and State agencies, local communities, tribes, regional entities, NGOs and others need integrated information and tools to manage resources at the landscape scale. The 2016 USGS budget provides $15.6 million in program increases for science to increase understanding of the Nation's landscapes, to inform decisions such as managing public lands, siting and mitigating resource development, and supporting conservation, recreation, and other land uses. Science activities include research for specific landscapes such as the Arctic, Columbia

River, Puget Sound, Upper Mississippi River, Great Lakes, sagebrush habitat, and coastal landscapes, and addressing landscape-level challenges associated with invasive species and species in decline.

Foundations for Land Management ($37.8 million) – Foundational to all work in landscapes and across the other science themes are data, tools, scientists and managers. These data and tools help land and resource managers make informed decisions across the landscape and provide data and information to the public for use in a wide variety of applications. The budget provides program increases totaling $37.8 million for foundational data and tools needed to support landscape level understanding. These activities include land imaging, mapping, expanded lidar collection through the 3D Elevation Program, making data more easy to access and use under the Big Earth Data Initiative, developing Landsat science products, and developing information and tools to assess ecosystem services and benefits. The budgets of both the USGS and NASA provide funding to sustain the Landsat data stream, which is critical to understanding global landscapes. The Landsat satellite program is funded at $77.6 million, $24.3 million above 2015, and includes funding for the maintenance and operation of ground systems and satellite operations. The successful launch of the Landsat 8 satellite in 2013 enables the continuation of the 42-year Landsat record. Following extensive study, the Administration has established a plan for a long-term Sustainable Land Imaging program that would extend the four-decade long Landsat series of measurements of the Earth's land surfaces for another two decades. The plan includes three simultaneous activities. The first is the initiation of a new U.S.-built small satellite with a thermal imager that would launch as soon as feasible, likely in 2019, and would operate either in conjunction with a European Sentinel-2 satellite or with the Landsat 8. The second activity would be the initiation of Landsat 9 as a rebuild of Landsat 8, with a target launch date in early 2023. The third activity is ongoing investment in technology development and systems innovation to reduce risk in next generation missions, including Landsat 10. In 2016, the USGS will work with NASA to support the Administration's plan for a Sustainable Land Imaging Program. The USGS is requesting $24.3 million to develop systems to operate the satellites and collect, archive, process, and distribute the data for the program. Additional funding requests to complete this effort will be made in future fiscal years.

Natural Hazard Science ($6.6 million) – In domestic and global events, the Nation's emergency managers and public officials look to USGS science to inform them of the risks hazards pose to human and natural systems, and how to reduce losses and improve response. In 2016, the USGS will strengthen its capabilities both before and after disasters strike. Included in the request is funding to continue earthquake early warning development, continue volcano monitoring, add to the streamgage network, support solar flare monitoring, expand the Global Seismic Network, improve landslide and sinkhole understanding and response, and develop a rapid response capacity for wildfires. Efforts in 2016 will deliver science to support disaster response, which will provide enhanced situational awareness and ultimately a Nation with greater resilience to natural hazards.

Science Infrastructure ($21.1 million) – Science Infrastructure includes the essential support functions, services, and facilities that form the foundation for the USGS science mission. Achieving high-quality science research, and delivering that science to decisionmakers, depends on having the required resources, including: scientific equipment and facilities; scientists and technicians; partnership agreements and contracts in place when needed; and the management processes to best utilize these resources. Included in the increase is funding to enhance science coordination, expand youth and education opportunities,

implement cost savings and sustainability efforts, and support the essential foundations and structures for management, finance, acquisition, safety, and information technology. The request for science infrastructure is commensurate with the requested increase for science funding, and will strengthen core capabilities and science support activities. Without these important increases in science infrastructure, science funding and activities would be directly impacted.

Administration and Secretarial Initiatives and Priorities

The USGS is a key contributor to Administration and Secretarial Initiatives and Priorities. The section below addresses USGS contributions in supporting specific Administration and Secretarial initiatives in 2016 that will help the USGS continue to advance these areas.

Strengthening Tribal Nations and Insular Communities

Strengthening Tribal Nations – The USGS Office of Tribal Relations (OTR) contributes to the strengthening of Tribal Nations in 2016 by continuing its innovative support for science programs at tribal colleges, such as Salish Kootenai College (SKC), where the OTR funds USGS scientists to collaborate with the staff of SKC's hydrology program and provide training as part of the curriculum, and at Haskell Indian Nations University, where the USGS provides support for the Indigenous Peoples Climate Change Working Group. The USGS will also continue to offer training opportunities such as those provided through its Technical Training in Support of Native American Relations Program, which provides support for in water quality, wildlife diseases, and the use of geospatial information systems for environmental assessments. Through its Student Interns in Support of Native American Relations internship program, the OTR will continue to fund interns to work on collaborative research between USGS and Tribes on reservation lands on such topics as avian and vegetative phenology in the Arctic, groundwater monitoring, and the use of beaver to restore ecosystem functions. By providing this support, the USGS helps to provide Native students and interns with opportunities to get science and workforce training for future careers in Federal service, private industry, or serving tribal communities in this time of tremendous environmental challenges.

Native American communities are increasingly engaging with the USGS and other partners to develop climate adaptation programs, and their need for scientific and planning information is likewise increasing. In 2014, the National Climate Change and Wildlife Science Center/Department of the Interior Climate Science Centers (NCCWSC/CSC) Program's Advisory Committee on Climate Change and Natural Resource Science recommended that the USGS convene tribal and indigenous partners from across the CSC network to identify common and high priority tribal needs. This recommendation aligns with the current strategy of the CSCs, where scientists work with tribes to identify high priority tribal resource management concerns and build a science portfolio that provides information directly responsive to these needs. In 2014, the NCCWSC/CSC Program continued to build relationships with tribes. The USGS, in cooperation with the Bureau of Indian Affairs, will host five Tribal Climate Scientist/Technical Support Liaisons to reside within the CSCs to improve delivery of climate science data and tools to support tribal climate adaptation planning efforts. The positions will also help to identify tribal science needs for integration into future USGS climate change research efforts. The Alaska, Southwest, Northwest and

North Central CSCs will each host a liaison, and the Northeast and Southeast CSCs will share a liaison. The South Central CSC already maintains its own liaison for its tribal engagement activities.

The USGS will continue to support opportunities for the integration of indigenous knowledge systems and Western science, develop innovative programs such as the Native Youth in Science – Preserving Our Homelands pilot summer camp, and engage in USGS tribal outreach efforts, such as those for tribes affected by Hurricane Sandy, that demonstrate to Indian Country how the USGS "gold standard" of research can help to address tribal science needs.

Powering Our Future and Responsible Use of the Nation's Resources

The USGS 2016 budget request for the President's All-of-the-Above Energy Strategy initiative is $43,451,000 and 21 FTE. This includes an increase of +$8,549,000 and +30 FTE above the 2015 Enacted level.

The economy, national security, and standard of living of the United States depend on adequate and reliable supplies of energy, balanced with the need to consider potential impacts from energy development and use. To ensure a balanced domestic energy portfolio, the President emphasizes an "all-of-the-above" strategy for energy development, and Interior has made safe and environmentally responsible domestic energy development a priority, with USGS science playing a central role in informing management decisions. Through early planning, thoughtful mitigation, and the application of sound science, Interior is working to support responsible use of resources, which includes not only traditional sources but also the further development of new, cleaner resources to help mitigate the causes of climate change, and using the best available science to choose the right places to develop. The full breadth of USGS science contributes to providing data, information, and knowledge in support of these efforts. Funding increases in FY 2016 support the following targeted studies:

- Characterize geothermal resources, and provide science support to agencies responsible for geothermal energy resource management on Federal lands;
- Support the collaborative interagency effort between the USGS, the Department of Energy (DOE), and the Environmental Protection Agency (EPA) to conduct science, research, and development aimed at understanding and reducing the potential environmental, health, and safety impacts of unconventional oil and gas resources;
- Develop multidisciplinary resource assessments that facilitate considerations of tradeoffs between the development of and protection of resources on the landscape;
- Evaluate landscape impacts from solar energy development construction, operations and maintenance, and conduct research on the impacts of wildlife mortality from wind turbines to support interagency collaborative efforts to develop mitigation tools and techniques and improve siting efficiency.

Engaging the Next Generation

The 2016 budget provides a $4.3 million increase above the 2015 Enacted level for investments in the Youth and Education in Science program, outreach to underserved communities, the Cooperative Research Units (CRU), and the Mendenhall Research Fellowship Program as part of the Engaging the Next Generation Secretarial priority. These increases will be used to leverage program resources in pursuit of achieving USGS strategic science goals. The Engaging the Next Generation Secretarial priority enhances and expands the Youth Stewardship of Natural and Cultural Resources Agency Priority Goal (APG). The USGS supports three of the goals within the Secretarial priority: Learn, Serve, and Work.

The USGS has a proud history of mentoring and engaging youth, providing a broad array of research and learning experiences to young people in the Earth and biological sciences, aimed at inspiring the pursuit of scientific careers and increasing science literacy. USGS engagement with youth covers a broad age range. Typically, outreach activities and science camps are aimed at elementary and secondary school students (Learn), while internship programs employ students in high school, undergraduate, and graduate school (Work). Programs such as GeoFORCE, a highly competitive pre-college program in rural southwest Texas and inner city Houston, provide hands-on science learning experiences for middle and high school students and pathways to other Earth science programs like EdMAP, which trains the next generation of geologic mappers. The USGS engages and hires postgraduate students that include young scientists between 26-35 years of age through the Mendenhall Research Fellowship Program. Partnerships, such as the USGS partnership with the Alaska Native Science and Engineering Program, can increase the number of indigenous American students pursuing science, technology, engineering, and math (STEM) degrees. The Presidential Early Career Award for Scientists and Engineers (PECASE)—the highest honor bestowed by the United States Government on science and engineering professionals in the early stages of their independent research careers—has been awarded to young USGS scientists each year since 2009. USGS volunteers are an important dynamic of the USGS culture (Serve). Scientists Emeriti volunteer their time to complete projects they began prior to retirement, provide mentorship to others, and pass on institutional knowledge. Citizen scientists provide real-time data to inform databases on hazards, plants, birds, amphibians, and more.

In 2014, USGS scientists and staff engaged more than 50,000 K-12 young people nationwide in activities that include science camps for children from every segment of our population, judging science fairs, hosting field trips, developing teacher workshops, and providing opportunities for children with special needs. The USGS continues its commitment to tribal programs, particularly its Native Youth in Science summer camp, which engages Native youth by relating science learned in the classroom to tribal culture and the environmental health of local lands. These developmental efforts are investments in the USGS workforce of the future, and provide opportunities to introduce young people to the Earth and biological sciences.

Ensuring Healthy Watersheds and Sustainable, Secure Water Supplies

The 2016 budget request for the USGS's contribution to WaterSMART is $30,950,000 and 33 FTE. This includes an increase of +$14,584,000 and +29 FTE above the 2015 Enacted level. As competition for water resources grows for irrigation of crops, serving cities and communities, energy production, and the

environment, the need for information and tools to aid water and natural resource managers grows. WaterSMART is an Interior initiative that leverages and directs existing expertise and resources within the USGS and the Bureau of Reclamation (Reclamation) toward addressing complex, national- and regional-scale water challenges. The primary focus of the USGS contribution to the WaterSMART initiative includes developing a national water census, better understanding of water budgets, and supporting environmentally sound water management. Leveraging expertise across multiple disciplines enables a broader focus to address these challenging issues in a time of growing competition for water resources. The USGS possesses the skills and foundational resources to provide water resource, ecosystem, and land use managers needed decision-support tools. The USGS expertise in understanding hydrologic cycle effects on water, human water use, and the ways in which water quality and quantity affect the natural environment is critical to addressing this issue. The USGS is coordinating an effort called the Open Water Data Initiative with Reclamation, the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (USACE), and the Department of Energy (DOE) to improve their ability to feed data into the water use databases in accordance with the SECURE Water Act (P.L. 111-11), and the President's Climate Action Plan.

In addition, the WaterSMART initiative focuses on drought impacts across the United States. Responding to drought patterns and managing the implications of limited water resources are primary drivers for many land and water management agencies. Given the persistent drought in multiple regions of the United States, the USGS proposes to better quantify changes in streamflow, precipitation, and groundwater availability under drought conditions, to link these findings with data on the impacts of drought on ecological systems, and to bring regional decisionmakers together to develop coordinated adaptive management plans for the complex consequences of severe and prolonged drought. In the 2016 budget request, the USGS proposes to build upon funding that was requested in the 2015 President's budget to develop a science-based decision process for understanding and managing the impacts of drought on various parts of the Central and Western United States, including California.

The 2016 budget request will allow the Water Resources Mission Area to continue to provide grants to State Water Resource Agencies to improve their ability to provide the base data at the necessary resolution for effective decisionmaking. Comprehensive water use information would be provided on an annual basis for the following sectors of water use: irrigation, public water supplies, thermoelectric cooling water, industrial self-supplied water, and aquaculture. In addition, water use would be estimated for the mining, livestock, and self-supplied domestic water use sectors.

Building a Landscape-Level Understanding of Our Resources

The USGS is on the front lines confronting landscape challenges on a daily basis, addressing more intense fire patterns, increasing sea-level rise, record breaking drought, shifting wildlife population ranges, warmer ocean temperatures, more extreme weather events, invasive species and changing habitat. The 2016 budget request proposes funding to improve understanding of the impacts of landscape change and to support adaptation to these changes on the ground. A few examples of the proposed investments follow.

Complex geographic areas are being impacted by natural and anthropogenic stressors, while demands for ecosystem services and development on these areas increase. Interior partners must make natural resource decisions about these regions, and have pressing needs to expand their understanding of landscape elements and interactions in these critical landscapes. Landscape understanding is also a critical component of implementing Secretarial Order Number 3330, "Improving Mitigation Policies and Practices of the Department of the Interior." In 2016, the USGS will work with partners in key ecosystems to identify landscape-scale issues and threats, assess existing and projected landscape conditions and impacts to species and habitats, and develop and implement monitoring and evaluation protocols and metrics.

The USGS will provide the science needed in these Critical Landscapes (Arctic, Columbia River, Puget Sound, etc.) by:

- Creating detailed understanding of the resources that are impacted by development, resource values to be protected, and identification of the current baseline status of these resources
- Providing quantitative understanding of threats and stressors such as the impacts associated with climate change, invasive species, and changing fire regimes
- Delivering decision-support tools needed to assist managers in evaluating options and the effects of various alternatives

Outcomes include providing the science decisionmakers need in:

- Protecting diversity of habitat, species, and communities
- Maintaining key ecosystem services, such as water flows, water quality, and storm protection
- Monitoring and preventing the spread of invasive species
- Focusing development activities in ecologically disturbed areas when possible, and avoiding ecologically sensitive landscapes, culturally sensitive areas, and crucial wildlife corridors
- Creating opportunities to build resilience by considering the cumulative effects of development, incorporating conservation principles such as habitat connectivity into landscape strategies, and ensuring that conservation and development activities take place within a landscape context

Building a 21st Century Department of the Interior

The USGS continually improves program performance by applying existing evidence about what works, generating new knowledge, and using experimentation and innovation to test new approaches to program delivery. The following are examples of efforts underway to improve program outcomes.

Climate Resilience – Among the most significant challenges of the changing climate is a projected increase in the frequency and intensity of extreme weather events—including severe storms, wildfire and drought. In 2016, Interior proposes investments to increase the resilience of both coastal and inland communities to the impacts of these events. These investments will focus on areas at high risk to climate

challenges to address vulnerabilities to extreme events in these geographies in partnership with State, local, and tribal governments and other stakeholders.

Given this challenge, the 2016 request for the USGS proposes investments in Adaptation and Resilience, Community Resilience Toolkit, Translational Science Grants, and Tribal Climate Science Partnerships in support of this effort.

WaterSMART – The USGS has relied substantially on recommendations made by the National Research Council to develop the 2016 WaterSMART Water Use Information Initiative. In 2002, the National Research Council (NRC) published its "Estimating Water Use in the United States, A New Paradigm for the National Water-Use Information Program." This document significantly laid out the measures that the USGS should take in building its current National Water Use Information Program (NWUIP) into a modern integrative water-use science program. The NRC review covered such aspects as the use of models and statistically based monitoring methods to provide better and timelier water use information. The USGS has spent 10 years working to position the NWUIP for a major initiative to implement many of the recommendations set forth in the NRC's review and the budget initiative for 2016 is the culmination of that effort.

Energy Resources Program Web Page – The Energy Resources Program **(**ERP) Web page is continually updated to improve the visibility of new research products and additional outlets, such as Twitter (with well over 10,000 followers), are used to immediately disseminate ERP products. The ERP periodically monitors what products are most requested and what type of customer is accessing our research. This information is being used to help develop a public survey to determine how effective the Web site is at delivering products. In addition, the ERP (along with the Mineral Resources Program), uses actual counts of specific product downloads as a success metric tracked by Interior. This helps to determine if ERP research priorities are reflected in customer needs.

Science Application for Risk Reduction (SAFRR) Project – The USGS is dedicated to the innovative application of hazards science to protect the safety, security, and economic well-being of the Nation. SAFRR builds upon USGS efforts in southern California that created the ARkStorm Flood Scenario and the ShakeOut Earthquake Scenario, an effort that led to the Great ShakeOut. The scenarios have engaged a wide range of partners and stakeholders in understanding the nature of the hazards facing the California community and working together to develop effective mitigation strategies. SAFRR is currently working with constituents to develop alternative early warning and short-term earthquake likelihood messages and to assess through focus group studies the effectiveness of our standard messages approaches. As natural hazards continue to threaten the safety, security, and economic well-being of our Nation's communities, these efforts will help to assess and improve the effectiveness of the user interface for all USGS Natural Hazards programs by providing a better understanding of the processes driving these hazards.

Improvements to the USGS Scientific Information Product Review and Approval Process – The Information Product Data System (IPDS) is a Web-based application that tracks and manages the scientific information product review and approval process. The newly designed IPDS was launched in June of 2013. This system was designed to provide immediate access to relevant process data and controls for all users, but especially authors. Streamlined workflows have reduced the amount of time

users must engage with the system while improving data quality and availability. This has enhanced the ability of scientists and their cost centers to track progress, make decisions, and address issues that arise during the information product review, approval and dissemination lifecycle. In addition, this system gathers critical bibliographic metadata that is used in the final information-product dissemination process. Improvements to the user interface and the implementation of a streamlined data model, which includes the assignment of Digital Object Identifiers, have resulted in more-timely release of information products that can be accessed and cited by researchers, resource managers, and the public.

Cost Savings and Innovation Plan – The Space Action Approval and Waiver **(**SAAW) process allows for all space actions to be evaluated, ensuring they meet policy, regardless of how the space is acquired. The process also allows the USGS to control the footprint, manage space holistically, and provides the data and analysis required to manage space according to the new departmental and OMB policies. The SAAW has preset thresholds for utilization rate, cost, term, and square footage increase/decrease that include five levels of management analysis. The SAAW form is used to determine whether the space action adheres to bureau policy that the action must have (1) a utilization of 180 usable square feet per person or less; (2) not increase the footprint; (3) not increase cost by more than 25 percent; and (4) must have cancellation rights.

Agency Priority Goals

Climate Change

The USGS is a contributor to the Climate Change Adaptation Agency Priority Goal (APG): *By September 30, 2015, the Department of the Interior will demonstrate "maturing" implementation of climate change adaptation, as scored when implementing strategies provided in its Strategic Sustainability Performance Plan*. In 2015, progress for improved climate change adaptation and collaboration across the Interior will include pursuing the following significant milestones:

- Establishment of climate change-adaptation guidance in all of the Interior land management bureaus, distributed throughout each bureau's regional offices and individual management units.
- Establishment of climate adaptation networks within each bureau and across the Department, with individual performance measures in place.
- New climate change adaptation data and decision tools relating to—
    - predicting and anticipating wildland fire trends
    - predicting the spread or introduction of invasive species
    - tracking changes in wildlife abundance and distribution
- Integrated vegetation surveys representing the entire lower 48 States.
- Creation of a Web-based searchable database of the vulnerability assessments prepared across all Federal land management agencies.

Bureau Contribution: The CLU Mission Area is the primary contributor from the USGS to this APG. The USGS funding for climate change in 2014 is $53.6 million, $57.6 million in 2015, and $82.6 million in the 2016 President's budget request.

Implementation Strategy: The Climate Change Adaptation APG presents an opportunity to unite climate change research and science conducted by Interior bureaus. Interior's implementation strategy for the Climate Change Adaptation APG includes:

- Mainstream and integrate climate change adaptation into both agencywide and regional planning efforts, in coordination with other Federal agencies as well as State and local partners, tribal governments, and private stakeholders: All eight CSCs now have permanent Federal directors, and the partner universities' science staffing at each CSC continues to grow, allowing the CSCs to expand their science outputs, ensure effective links with other partners, and conduct effective program operations. All CSCs have five-year strategic plans that outline regional science priorities. These plans, with ongoing stakeholder input, are used to guide annual science planning and funding decisions. In 2016, the CSCs will continue to focus on high-priority science that identifies potential impacts to various natural and cultural resources, and will expand collaboration with other science providers in these focus areas. The NCCWSC has created a national science plan to provide a framework for the climate change- impact research conducted or coordinated by the NCCWSC. This plan also establishes a context for regional and national synthesis of science products and information across the CSC network.
- Ensure agency principals demonstrate commitment to adaptation efforts through internal communications and policies: The USGS has established the CLU science strategy that provides a number of high-level goals for CLU Mission Area programs and is a vehicle for scientists and partners to get a general overview of our activities. The plan outlines seven broad goals for USGS climate change science for the coming decade: (1) rates, causes, and impacts of past global changes; (2) global carbon cycle; (3) biogeochemical cycles and their coupled interactions; (4) land use and land cover change rates, causes and consequences; (5) droughts, floods, and water availability under changing land use and climatic conditions; (6) coastal response to sea-level rise, climatic change and human development; and (7) biological responses to global change. In addition, annual guidance documents, issued by the CLU Mission Area, provide field units with operational guidance about priorities and objectives.
- Ensure workforce protocols and policies reflect projected human health and safety impacts of climate change: The USGS will continue to ensure employee awareness of telework opportunities and protocols. Currently through the end of the third quarter of 2014, about 94 percent of USGS employees are eligible to telework and of those eligible employees, about 37 percent telework on a regular basis.
- Design and construct new or modify/manage existing agency facilities and infrastructure with consideration for the potential impact of projected climate change: The USGS is working with Interior on a vulnerability assessment tool to address the USGS real property inventory. The focus of the vulnerability tool is to evaluate the effects of climate change such as sea-level rise, storm surge frequency and elevation, air temperature changes, and precipitation changes on the USGS real property portfolio.

- Update agency external programs and policies to incentivize planning for and addressing the impacts of climate change: The USGS provides external funding to support and facilitate climate adaptation. Each CSC is a Federal-university collaboration, and develops a science portfolio in consultation with regional resource managers and science partners. Specifically, in 2016, the NCCWSC/CSC Program requests an increase of $10.6 million to strengthen this work, focusing on interagency and regional coordination of climate science and adaptation planning activities; developing actionable science focused on decisionmakers' needs, including providing science to better integrate climate mitigation and adaptation planning, ecological drought and changes in the Arctic; and addressing Native American tribal nations' needs for climate science.

Performance Metrics: The Annual Performance Plan and Report contains details of the USGS performance metrics.

Youth Stewardship of Natural and Cultural Resources

The USGS is a contributor to the Youth Stewardship of Natural and Cultural Resources APG: By September 30, 2017, the Department of the Interior will provide 100,000 work and training opportunities over four fiscal years, 2014 through 2017, for individuals age 15 to 25 to support the mission of the Department.

Bureau Contribution: The USGS contributes to Interior's goal by engaging youth through meaningful hands-on work experience, training, professional mentoring and graduate research in the natural sciences. Increasing the number of youth hired at the USGS is critical to achieving the USGS mission now and in the future. The USGS budget contribution to Youth Stewardship of Natural and Cultural Resources in 2014 was $23.7 million, $23.7 million in 2015, and is $28.0 million in the 2016 budget request to continue these investments in the Secretarial priority, Engaging the Next Generation. In addition to this funding, base funding is used to support Youth activities in many USGS programs. The USGS employed an additional 55 youth in 2014, as compared to 2013.

Implementation Strategy: The USGS has a rich culture of mentoring, engaging, employing, and educating youth in the Earth and biological sciences. The USGS implemented a Youth and Education in Science Program, effectively merging the Youth and Education offices in 2015 to leverage resources, achieve efficiency, provide a consistent program and process methodology, and increase strategic vision to engage the next generation in USGS science goals. The USGS is tracking new and current youth hires and youth hired by our partners; is enhancing participation in the sciences by women, Native Americans, and other underrepresented students; is providing training and experiences in the natural sciences outdoors; and is creating science career pathways that reach out to students in grades K-16. Below are some examples of USGS program participation:

- GeoFORCE is a powerful, highly competitive pre-college program that provides spectacular, hands-on science learning experiences for talented middle and high school students from rural Southwest Texas and inner city Houston. The goal is to encourage underserved minority youth to excel in the sciences and pursue higher education in scientific fields. In 2015, USGS scientists continued to lead programs in the field, lead tours of USGS Headquarters and laboratories, and financially support the hiring of GeoFORCE counsellors, who are primarily geology majors from various universities. In 2014 and 2015, the USGS hired graduating GeoFORCE students as

interns for science programs. The demographics show that about 80 percent of the GeoFORCE students are of minority background including Hispanics, African Americans, Asians, and Native Americans. The success of the program is measured by the fact that 100 percent of GeoFORCE students graduate from high school, 96 percent gaining admission to college, and 64 percent declare STEM majors, many of which go into geology or related earth sciences.

- The USGS and the Denver Mayor's Office initiated a collaborative employment partnership in 2011 aimed at promising inner city, at-risk youth. The Denver Mayor's Office screened students and provided life skills training. The USGS interviewed, selected, and provided meaningful work assignments. The USGS also provided a mentor, field trips to diverse science activities, and group counseling sessions. The initial 2011 cohort had 14 students from either high school or beginning college. In 2012, the Partnership included the Albuquerque Mayor's Office, and a cohort of 21 students. The Partnership was suspended in 2013 due to Sequestration, restarted in Denver in 2014, and plans to expand to Albuquerque and Flagstaff in 2015 and 2016.
- In 2015, the National Association of Geoscience Teachers (NAGT)/USGS Cooperative Summer Field Training Program marked the 50th year of what is now the longest running STEM internship program in the Nation. Over 2,200 students have participated in this program, with an impressive number of participants moving on to distinguished careers with the USGS, academia, or industry. While the majority of these interns go on to graduate school, over one-third who have participated in the program have become permanent hires of the USGS. The Youth and Education in Science Program manages and oversees all aspects of the NAGT/USGS Internship Program, including the collection of evaluations by both interns and science mentors that are conducted annually, with results distributed in an annual report to all cooperating parties.

The USGS doubled the number of youth hired by partners through a national cooperative agreement with the Conservation Legacy – Environmental Stewards Corps program, which enabled the bureau to receive a DOI private grant for Corps student interns. The development and startup of the Youth and Education in Science Council in 2015 will further align the Youth Stewardship of Natural and Cultural Resources APG and the Engaging the Next Generation goals with the USGS strategic science direction. The USGS will continue to engage the next generation in 2016 by working with science centers and offices, leveraging resources, investing strategically to accomplish bureau workforce planning and Secretarial goals, and contributing to the development of a future STEM workforce that will participate in building the economy of our Nation.

Performance Metrics: The Annual Performance Plan and Report contains details of the USGS performance metrics.

President's Management Agenda

The Department of the Interior supports the President's Management Agenda to build a better government, one that delivers continually improving results for the American people and renews their faith in government. The USGS is activity involved in the governmentwide effort to bring forward the most promising ideas to improve government effectiveness, efficiency, spur economic growth, and promote people and culture. The USGS supports achievement of the President's Management Agenda objectives in these four pillars as described below:

Effectiveness:

Management Effectiveness – The USGS is committed to achieving the Administration's challenge for gaining greater Federal effectiveness by focusing on agency top priorities, cutting waste, improving information technology, promoting accountability and innovation through open government, and attracting and motivating top talent. To meet this goal, the USGS is reviewing programs for savings opportunities and effectiveness, and implementing new ideas to increase the effectiveness and efficiency of bureau operations.

In 2012, the USGS chartered a bureauwide process to examine all aspects of the USGS for efficiency and effectiveness and encourage innovation. This process, Achieving Cost Efficiencies for Science (ACES), resulted in a data driven analysis of facilities utilization, science center efficiencies, science management and programming organization and structure, administrative and technology services, headquarters and regional functions. Subsequently, the USGS Executive Leadership Team implemented business decisions such as merging organizational units into a smaller number of USGS regional offices, creating better administrative and organizational efficiencies; consolidating the facilities footprint of science centers; and streamlining required business processes.

Efficiency:

Energy Efficiency and Environmental Management – The USGS developed a $12.0 million, alternatively financed, Energy Savings Performance Contract (ESPC) that was awarded in the third quarter of 2014. Expected energy savings of over $650,000 per year, and water savings over $17,000 per year will pay for facilities improvements at three USGS locations. When completed, the energy conservation measures are expected to reduce facility energy consumption and greenhouse gas emissions. The ESPC will reduce the USGS's energy consumption by 15 percent, and will reduce potable water use by five percent. The ESPC is paid with energy savings so there is no capital investment from Federal funding. This effort supports the President's Performance Contracting Challenge.

Consolidations and Savings – In 2012 and 2013, the Cost Savings and Innovation Plan (CSIP) provided the USGS the ability to reduce its footprint by more than 400,000 rentable square feet (RSF). These efforts came from its three major centers: Reston, VA; Denver, CO; and Menlo Park, CA. Each of these centers were successful in taking on major consolidation projects, reducing space requirements, actively seeking co-location opportunities and vacating more expensive space. The achieved results were the direct impact of the bureau's CSIP initiative. The USGS goals under the CSIP are to reduce its footprint and costs; move toward the 180 square foot (SF) per person utilization standard; and utilize space more efficiently by implementing advanced computer technology and programs such as teleworking.

In 2013, the USGS achieved the required cost reduction target of $9.0 million set forth by Interior's Cost Savings Plan Policy. In addition to meeting 2013 levels, the USGS has already achieved savings of $1.7 million (through space reduction and cost avoidance measures) for 2014. Since the CSIP program efforts began in 2012, the USGS has reduced its footprint by approximately 570,000 RSF, 10 percent of its total portfolio.

Economic Growth:

According to a 2014 report (*https://www.fgdc.gov/ngac/meetings/december-2014/ngac-landsat-economic-value-paper-2014-update.pdf*) from the Landsat Advisory Group of the National Geospatial Advisory Committee, the economic value of just one year of Landsat data far exceeds the multi-year total cost of building, launching, and managing Landsat satellites and sensors. One example of this is how the E&J Gallo Winery, the world's largest family-owned winery and the largest exporter of California wine, uses multi-temporal Landsat imagery to closely manage its vineyard irrigation schedules and its water use, and to monitor California vineyard production statewide. "At Gallo, everyone understands the value of Landsat in their operations, from the vineyard manager up to the Vice President level," states Martin Mendez-Costabel, Gallo's Manager of Geographic Information System and Remote Sensing. During the grape growing season, Gallo downloads every available Landsat image captured over California's agricultural lands. While all Landsat bands are important to Gallo's efforts, the thermal bands have the greatest value because they can be used to monitor evapotranspiration. "With grapes, we want to impose water stress because there is a strong correlation between water stress and good wine quality," states Mendez-Costabel. The thermal bands, Landsat's eight-day revisit time, and the high quality of Landsat image calibration are critical to supporting the fast paced and high precision management decisions made at Gallo.

Because only Landsat imagery provides weekly revisits of regionwide thermal imagery, Gallo would be unable to conduct their detailed water management and conservation efforts without creating a separate company to develop, build and collect airborne thermal imagery—an endeavor estimated to cost at least $3 to 5 million per year.

Elevation data are essential for flood mitigation, conservation management, infrastructure development, national security, and many other applications. In 2015, the USGS developed a 3D Elevation Program (3DEP) initiative to respond to growing needs for high-quality topographic data and a wide range of other three-dimensional representations of the Nation's natural and constructed features. A National Enhanced Elevation Assessment (NEEA) study was conducted under a contract between the USGS and Dewberry (a consulting firm based in Fairfax, VA); additional support for the assessment came from other Federal agencies: the Federal Emergency Management Agency, the National Geospatial-Intelligence Agency, the National Oceanic and Atmospheric Administration, and the Natural Resources Conservation Service. The NEAA study was conducted to (1) document national level requirements for enhanced elevation data, (2) estimate the benefits and costs of meeting those requirements, and (3) evaluate multiple national enhanced elevation program scenarios. Based on the NEEA results, the 3DEP initiative could return more than $690 million annually in new economic benefits to the private sector and citizens through improved government program services. Return on investment would be nearly 5:1, save lives, and improve the environment through informed decisions. Further, 3DEP leverages the capacity and expertise of private industry mapping firms and will promote job creation in the short and long term as data availability spurs innovation and analysis for years to come.

People and Culture:

Building a Highly Motivated Workforce and Attracting Top Talent – The USGS promotes a culture of employee engagement. High levels of employee participation helped make the USGS among the best places to work even in a period of fiscal austerity. In 2013, the USGS ranked 64 out of 300 agency subcomponents for "The Best Places to Work" in the Federal Government, as reported by the Partnership for Public Service, drawing on data from the OPM Federal Employee Viewpoint Survey (FEVS). In addition, the USGS was the top rated Interior bureau on the same survey. The USGS was also deemed the top agency at employee engagement in the 2013 Ragan Employee Communications Awards from among hundreds of private sector firms. The USGS was the first among Interior agencies to receive this recognition.

The USGS strives to attract and retain a diverse cadre of top performing scientists, managers, and support personnel. USGS leadership actively solicits input from its employees to identify opportunities for improvements with the benefit of those dealing with day-to-day operational realities. To engage employees across all levels, the USGS uses technology to promote a free and open dialogue with employees. For example, USGS executive leadership communicates on operational issues across the bureau through the USGS Leaders Blog and town hall meetings, and solicits employee suggestions through the IdeaLab.

As part of its effort to attract and develop top performers, the USGS collaborates closely with programs to hire and engage student interns through the Pathways Hiring Authority, cooperative agreements with Corps organizations, student services contracts and grants through universities. These intern programs help the USGS to close the skills gaps needed for positions such as the Hydrologic Technician career path. Hydrologic Technicians constitute one of the top two career series within the USGS, with 25 percent vacancies estimated from retirements or other departures from the USGS in the next three to five years. The Hydrologic Technician Interest Committee, comprised of USGS leaders in Hydrology across the Nation, strives to achieve career placements with an overall goal to hire the best candidates with a focus on veterans, youth, and diversity. Through flexible and varied hiring authorities and options, youth enjoy a combination of work experience, mentoring, and sharing, guided by highly experienced staff that will help the USGS to ensure continuity of services; the ability to reach strategic science goals; and implement an effective USGS succession plan.

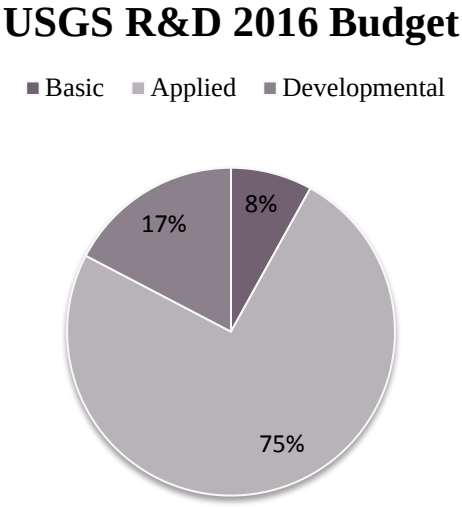
In 2012 and 2013, the USGS conducted workforce planning at higher levels in the organization, specifically in mission areas, regions, and offices, to assist the USGS in identifying future skills and competencies to facilitate broader programmatic changes and identify the future workforce needed to meet the requirements associated with those changes. Multiple higher-level workforce plans identified Voluntary Early Retirement Authority (VERA) and Voluntary Separation Incentive Payment (VSIP) as tools that would facilitate their ability to reshape their workforces with new skills and capabilities to accomplish their missions and programs while avoiding a potential furlough or reduction in force (RIF) actions. As a result of the USGS's workforce planning effort, the USGS leadership recognized a compelling need for developing broader VSIP authority requests for mission area, region, and office levels, and for pursuing a bureauwide VERA. These tools were used to begin reshaping the USGS workforce with new skills and capabilities to accomplish the science mission and programs while

avoiding potential furlough or RIF actions. The bureau's usage of integrated requests from mission areas, regions, and offices demonstrates a broad, strategic, and coordinated approach to organizational re-engineering to achieve a technically diverse, competent, and flexible workforce that will further the USGS's strategic direction. In 2013 and 2014 to date, the USGS received approval from the Office of Personnel Management (OPM), with OMB concurrence, for several requests for VSIP and VERA, covering entire mission areas, regions, and offices, and later for a bureauwide VERA.

Another result of this workforce planning effort is the development of a USGS Workforce Plan, to identify actions needed at the bureau level to ensure the USGS has the workforce needed to continue its leadership in Earth science. A bureau workforce plan, being finalized in 2014, will outline strategies and actions to ensure the USGS has the workforce it needs to deliver the USGS science mission and goals.

National Science Perspective

Research and Development – Investments in Research and Development (R&D) promote economic growth and innovation and ensure American competitiveness in a global market. R&D is the core of the USGS mission. To ensure that R&D funding is tracked consistently, each program identifies the percentage of the program that fits into the categories of basic, applied, and developmental research. The percentage is then applied to total funding provided. The percentages are revisited periodically to ensure that they accurately reflect the research portfolio. This approach provides a manageable and consistent manner to track R&D costs across science activities and fiscal years.



R&D funding in the 2016 request is $761.1 million, which is 63.7 percent of the total USGS requested budget and an increase of $95.3 million above 2015 enacted. All USGS basic, applied, and developmental research ultimately supports the goal of providing the scientific framework for decisionmaking.

The OMB Circular A-11, Section 84, defines the three categories of research and development. Basic research includes studies to gain fuller knowledge or understanding of the fundamental aspects without specific applications in mind. Applied research includes studies to gain knowledge or understanding necessary to determine if a specific need may be met. Developmental research includes the application of knowledge or understanding, directed toward a tool, method, or device, including design, development, and improvement of prototypes and new processes to meet specific requirements. All three components are essential for a robust, innovative, and successful science program; the USGS invests in all three components.

Science Integrity – The USGS is committed to providing high quality science and has a vested interest in ensuring its science is seen as credible and trustworthy. In October 2010, the USGS established the Office of Science Quality and Integrity (OSQI). The OSQI is responsible for establishing and implementing standards for scientific integrity and excellence and administering programs for ethics, education, development, and collaboration including the USGS Office of Ethics, the National Youth program, the Mendenhall Postdoctoral Fellowships, bureauwide education activities, and the Office of Tribal Relations. The office works closely with management, programs, and human resources across the USGS, with Interior, OSTP, NSF, the National Academy of Sciences, and other governmental and non-governmental agencies.

The OSQI provides internal controls to the Office of Management and Budget (OMB) based on Fundamental Science Practices (FSP) and the Information Product Data System (IPDS), which demonstrates the evidentiary process for maintaining the quality of USGS science. Linkages are in place that ensures science quality best practices are followed for approving and releasing publications; helping the USGS grow the next generation of Federal scientists through the Mendenhall Research Fellowship Program, college, and high school internships; evaluating USGS research, development, and senior scientists; and maintaining scientific knowledge based associations through scientist emeritus. In 2014, a 7,315 products were approved in compliance with FSP and tracked using IPDS—4,047 new interpretive products were approved by Bureau Approving Officials in OSQI, and 3,268 interpretive (previously published) and (or) non-interpretive products were approved at the USGS science center level. Additionally, in 2014, OSQI completed the Mendenhall Fellows Recruitment - Round 14, which resulted in the hiring of 29 new Mendenhall postdoctoral fellows in 2014 and 2015.

Strategic Plans

USGS Science Strategy

The USGS manages its budget for results by defining and continually assessing core mission priorities that align with Interior's Strategic Plan, including deliberate strategies, performance measures, and priority goals as the basis for a multi-year planning and annual operating plans. These include comprehensive reviews of programmatic priorities and consideration of high-risk areas. In 2007, the USGS published a 10-year Science Strategy that identified goals and priorities, representing all bureau capabilities and focused on challenges for the future. In 2013, each mission area developed more detailed Science Strategy Plans (SSPs) that outlined specific actions and directions to strengthen the USGS's role

as a premier science agency that provides information needed to meet the challenges of the 21st century. Investments proposed in 2016 continue or initiate actions and directions outlined in these plans.

DOI Strategic Plan

In 2014, Interior published the 2014–2018 DOI Strategic Plan (Plan), in compliance with the principles of the Government Performance and Results Act (GPRA) Modernization Act of 2010. The Plan provides a collection of mission objectives, goals, strategies, and corresponding metrics that enable an integrated and focused approach for tracking performance across a wide range of Interior programs. The Plan for 2014–2018 is the foundational structure for the description of program performance measurement and planning for the 2016 President's budget; further details for achieving the Strategic Plan's goals are presented in the Interior Annual Performance Plan and Report (APP&R). USGS science strategy plans are fully consistent with the goals, outcomes, and measures described in the Plan and related implementation information in the APP&R.

The USGS contributes to the following Goals and Strategies of the DOI Strategic Plan:

Goal #1: Provide Shared Landscape-Level Management and Planning Tools
Strategy #1: Ensure the use of landscape-level capabilities and mitigation actions

The USGS works with its many partners to deliver a comprehensive and high-resolution characterization of the Nation's land surface. Modern mapping includes Earth observations from many platforms (such as satellites and aircraft) and uses continuously evolving technologies that can sense and map an expanding list of features using the latest technologies. Highly accurate elevation maps and data, for example, are essential for hazards mitigation, conservation, infrastructure development, national security, coastal shoreline erosion, and many other applications. The benefits apply to flood risk management, agriculture and precision farming, water supply, homeland security, renewable energy, aviation safety, and other activities. Specific examples demonstrating the benefits of geospatial information include emergency responders for search and rescue missions, FEMA for preliminary damage assessments and rebuilding efforts from natural disasters, and entrepreneurial companies for mobile device applications. Although US Topo maps are updated on a three-year cycle, all geospatial layers regardless of vintage are archived and continue to provide value to the public for historical trends. Hawaii and Puerto Rico topographic maps have also recently been revised.

Goal #2: Provide Science to Understand, Model, and Predict Ecosystem, Climate, and Land Use Changes at Targeted and Landscape levels
Strategy #1: Identify and predict ecosystem and land use change

The USGS Ecosystems strategic objective supports regional and nationwide monitoring of key indicators of the environmental variability of terrestrial, freshwater, and marine habitats, along with the abundance and distribution of biota, invasive species, wildlife disease, and other ecological features. USGS data holdings and observation networks are unparalleled, difficult to duplicate, and vital to understanding the status and trends and health of our Nation's ecosystems and natural resources. Many of these databases include decades-long records of observations, collected under strict standards of quality assurance and

quality control. These programs fill a key role in adaptive management for the Nation's Ecosystems. Data from Landsat and other land-observing systems operated by the USGS are vital for scientists to understand changes occurring on the Earth's land surface, and to model their impacts for land and resource managers. Socioeconomic data shows a significant return on Landsat investments, with productivity enhancements and cost savings in the public and private sectors. For example, a study demonstrates the potential for approximately $100 million annual savings by using Landsat-derived applications for better water management for irrigated agriculture in the Western United States. One such product is the National Land Cover Database (NLCD), produced by the USGS in cooperation with a consortium of Federal partners. The NLCD supports thousands of science applications in the private, public, and academic sectors, and offers the only national database portraying land cover change spatially as a comprehensive "wall-to-wall" 30-meter cell database. It also provides a critical data layer in national assessments of biological carbon sequestration, water-quality monitoring, wildfire monitoring and modeling, and biodiversity conservation efforts.

Goal #2: Provide Science to Understand, Model, and Predict Ecosystem, Climate, and Land Use Changes at Targeted and Landscape levels
Strategy #2: Assess and forecast climate change and its effects

The USGS provides scientific research on patterns and impacts of climate and land use change on Earth and human systems. The understanding of these impacts is communicated through peer-reviewed journal articles, vulnerability assessments, resource assessments, forecasts, models and maps to advance the science of climate change and to support land and resource managers and policymakers in their decision making to manage and mitigate the impacts of climate change. The performance of the USGS National Climate Change and Wildlife Science Center and DOI Climate Science Centers are meeting the strategic goals outlined in Secretarial Order 3289.

Goal #3: Provide Scientific Data to Protect, Instruct, and Inform Communities
Strategy #1: Monitor and assess natural hazards risk and resilience

The USGS works with its many partners to characterize the potential impact and consequences of natural hazard events on human activity, health, the economy, and the environment. The USGS supports national and global monitoring capabilities and long-term investigations of earthquakes, volcanic eruptions, landslides and geomagnetic storms. Timely and relevant data, maps and assessments are provided to support emergency response and decrease loss of life and property due to a wide range of natural hazards.

Goal #3: Provide Scientific Data to Protect, Instruct, and Inform Communities
Strategy #2: Provide environmental health science to guide decisionmaking

The USGS Environmental Health strategic objective provides data, knowledge, and tools on the occurrence, behavior, and effects of environmental contaminants, including their impacts on susceptible ecosystems and implications for human health and the health of aquatic and terrestrial organisms. These capabilities help to inform decision making made by industry and the public, and helps resource managers and policymakers assess environmental risks; prevent contamination; license and approve chemicals; and

manage, protect, and restore natural resources, contaminated lands, and important natural ecosystems, including trust resources of the Department of the Interior.

Goal #4: Provide Water and Land Data to Customers
Strategy #1: Monitor and assess water availability and quality

Water science actively promotes the use of information by decision makers to minimize loss of life and property as a result of water-related natural hazards, such as floods, droughts, and land movement; effectively manage groundwater and surface water resources for domestic, agricultural, commercial, industrial, recreational, and ecological uses; protect and enhance water resources for human health, aquatic health, and environmental quality; and contribute to the wise physical and economic development of our Nation's resources for the benefit of present and future generations.

Goal #4: Provide Water and Land Data to Customers
Strategy #2: Generate Geologic Maps

The USGS conducts national-focused Earth-system science, along with its many partners, to deliver an understanding of the Earth’s complex geologic structure. Products include interpretive studies, scientific publications, three-dimensional geologic models, and geologic maps, all of which are essential for informed public policy decision making and economic development. Detailed, accurate information about the nature and origin of the geology of an area, portrayed through geologic maps and three-dimensional frameworks, is essential for identifying mineral, oil, and gas resources, finding and protecting groundwater, guiding earthquake damage prediction, identifying landslide and post-wildfire hazards, guiding transportation planning, and generally improving the quality of life and economic vitality of the Nation.

Goal #4: Provide Water and Land Data to Customers
Strategy #3: Assess national and international energy and mineral resources

The USGS provides research, assessments, maps, and data to communicate national and global energy and mineral resource accumulation, distribution, and potential. These products are provided to resource managers and policymakers to support informed policy and management decisions on land and resource use and the evaluation of trade-offs and environmental risks.

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Technical Adjustments

Technical Adjustments

Water Resources Mission Area Budget Restructure

Background

The U.S. Geological Survey (USGS) Water Science Strategy (Strategy), outlined in Circular 1383-G *Observing, Understanding, Predicting, and Delivering Water Science to the Nation*, identifies water science goals and objectives that serve the Nation and address water challenges for the future. The Strategy outlines areas where hydrologic science can make substantial contributions to society and identifies opportunities for the USGS to better use its hydrologic science capabilities to address National priorities to ensure healthy watersheds and sustainable, secure water supplies. In doing so, the Strategy is intended to inform long-term approaches to USGS program planning, technology investment, partnership development, and workforce and human capital strategies. The choice of strategic water science priority actions, goals and objectives is based on the guiding principles to *observe, understand, predict* and *deliver* water information that allows society to meet the water challenges of the Nation, current and future. While the Strategy does not cover all facets of USGS work in hydrology, it builds on a hierarchy of planning documents and provides a science-based response to the overarching issues of water availability and hydrologic hazards.

In order to achieve the Strategy vision, it is critical to align the budget and funding decisions with the Strategy's goals and objectives. In 2016, the USGS plans to align the Water Resources Mission Area budget structure to the Water Science Strategy by consolidating its seven existing programs into four major program areas. The Groundwater and Streamflow Information Program, primarily focuses on *Observing and Delivering*. The other three programs, the National Water Quality Program; the Water Availability and Use Science Program; and the Water Resources Research Act primarily focus on *Understanding, Predicting, and Delivering*.

The former budget structure features seven budget subactivities for the USGS Water Resources Mission Area:

- Groundwater Resources
- National Water Quality Assessment
- National Streamflow Information Program
- Hydrologic Research and Development
- Hydrologic Networks and Analysis
- Cooperative Water Program
- Water Resources Research Act Program

Budget Structure Realignment

In 2016, the USGS proposes to realign the Water Resources Mission Area budget structure. The following tables crosswalk the current budget structure to the proposed structure for funding in the 2014 Enacted, the 2015 Enacted, and the 2016 President's budget levels.

The 2016 congressional justification is written to the proposed structure. The Water Resources Mission Area chapter begins with a budget table in the proposed budget restructure, followed by the summary of proposed program changes, an activity overview, a management summary, and the performance changes.

The following tables are crosswalks from the current budget structure to the proposed budget restructure for the Water Resources Mission Area in the 2014 Enacted, the 2015 Enacted, and the 2016 President's budget levels. To further describe the realignment, a table is included which crosswalks the funding from the former activity to the new structure:

New Budget Activities $000	2014 Actual	2015 Enacted	2016 Budget Request	Change from 2015 Enacted	% Change from 2015 Enacted
Water Resources					
Water Availability and Use Science Program	38,544	40,919	46,758	5,839	14%
Groundwater and Streamflow Information Program	66,069	69,707	73,533	3,826	5%
National Water Quality Program	96,168	94,141	96,087	1,946	2%
Water Resources Research Act Program	6,500	6,500	6,500	0	0%
Total	**207,281**	**211,267**	**222,878**	**11,611**	**5%**

Former Budget Activities $000	2014 Actual	2015 Enacted	2016 Budget Request	Change from 2015 Enacted	% Change from 2015 Enacted
Water Resources					
Groundwater Resources	8,948	11,348	12,528	1,180	10%
National Water Quality Assessment	58,859	59,459	61,628	2,169	4%
National Streamflow Information Program	33,701	34,901	37,286	2,385	7%
Hydrologic Research & Development	10,915	11,215	12,639	1,424	13%
Hydrologic Networks & Analysis	28,884	30,134	31,588	1,454	5%
Cooperative Water Program	59,474	57,710	60,709	2,999	5%
Water Resources Research Act Program	6,500	6,500	6,500	0	0%
Total Water Resources	**207,281**	**211,267**	**222,878**	**11,611**	**5%**

2014 Actual

Former Budget Subactivities
Surveys, Investigations and Research
($000)

	New Budget Subactivities				
	Water Availability and Use Science Program	Groundwater and Streamflow Information Program	National Water Quality Program	Water Resources Research Act Program	Old Program Totals
Groundwater Resources	8,203	745			8,948
National Water Quality Assessment		229	58,630		58,859
Hydrologic Research & Development	5,345	1,150	4,420		10,915
National Streamflow Information Program	1,468	32,233			33,701
Hydrologic Networks & Analysis	12,528	712	15,644		28,884
Cooperative Water Program	11,000	31,000	17,474		59,474
Water Resources Research Act Program				6,500	6,500
Total SIR for New Programs	**38,544**	**66,069**	**96,168**	**6,500**	207,281

2015 Enacted

Former Budget Subactivities
Surveys, Investigations and Research
($000)

	New Budget Subactivities				
	Water Availability and Use Science Program	Groundwater and Streamflow Information Program	National Water Quality Program	Water Resources Research Act Program	Old Program Totals
Groundwater Resources	7,645	3,703			11,348
National Water Quality Assessment		229	59,230		59,459
Hydrologic Research & Development	4,976	2,351	3,888		11,215
National Streamflow Information Program	1,461	33,440			34,901
Hydrologic Networks & Analysis	15,441	185	14,508		30,134
Cooperative Water Program	11,396	29,799	16,515		57,710
Water Resources Research Act Program				6,500	6,500
Total SIR for New Programs	**40,919**	**69,707**	**94,141**	**6,500**	211,267

2016 Request
Former Budget Subactivities
Surveys, Investigations and Research
($000)

	New Budget Subactivities						
	Water Availability and Use Science Program	Groundwater and Streamflow Information Program	National Water Quality Program	Water Resources Research Act Program	Restructured to the Priority Ecosystems - Environments Program	Restructured to the Land Subsidence Effort - Coastal and Marine Geology Program	Old Program Totals
Groundwater Resources Program	7,808	4,720					12,528
National Water Quality Assessment Program		229	61,399				61,628
Hydrologic Research & Development Program	5,713	2,280	4,646			174	12,639
National Streamflow Information Program	1,861	35,425					37,286
Hydrologic Networks & Analysis Program	18,830	184	12,574		2,191		31,588
Cooperative Water Program	12,546	30,695	17,468				60,709
Water Resources Research Act Program				6,500			6,500
Total SIR for New Programs	**46,758**	**73,533**	**96,087**	**6,500**	2,191	174	222,878

Water Availability and Use Science Program

The Water Availability and Use Science Program will encompass the Water Resources Mission Area's objectives to provide comprehensive water availability and use science to the Nation. This program also fulfills the goal stated in the SECURE Water Act (P.L. 111-11), Section 9508, to establish a "national water availability and use assessment program." The Water Availability and Use Science Program will synthesize and report information at the regional and national scales, with an emphasis on compiling and reporting the information in a way that is useful to states, tribes, and others responsible for water management and natural-resource issues.

This program will include the USGS National Water Use Information activities, most of the Water Resources Mission Area components of the WaterSMART Initiative, the Water Energy Food Nexus work, Environmental flows, the regional groundwater availability evaluations, drought science activities, and all water availability analyses and research conducted in the Water Resources Mission Area through its current Hydrologic Research and Development and Cooperative Water Programs. This program will also be responsible for the support of information management functions that are vital to the dissemination of water availability and use scientific information.

$000 Water Resources Mission Area	Water Availability and Use Science Program		
	2014 Actual	2015 Enacted	2016 Request
Groundwater Resources Program	8,203	7,645	7,808
Hydrologic Research & Development Program	5,345	4,976	5,713
National Streamflow Information Program	1,468	1,461	1,861
Hydrologic Networks & Analysis Program	12,528	15,441	18,830
Cooperative Water Program	11,000	11,396	12,546

Groundwater and Streamflow Information Program

The Groundwater and Streamflow Information Program will encompass the Water Resources Mission Area's objectives to collect, manage, and disseminate hydrologic information in real time, over the long-term, and in a consistent manner. This is done in order to minimize loss of life and property from water hazards and to protect, manage, and sustain water that is safe and available for drinking and for other competing water demands, including irrigation, energy, industry, recreation, and healthy ecosystems. The USGS has been recognized as one of the primary national sources of impartial, timely, rigorous, and relevant data for water decisions by local, State, tribal, regional, and national stakeholders, both in the short and long term. Short-term water decisions are needed for flood forecasting, emergency response, reservoir releases, water-use restrictions, drinking water supplies, and recreation. Long-term decisions are needed for water-supply planning, infrastructure design, water quality protection and enhancement, floodplain and ecosystem management, energy development, resolving interstate, international, and tribal water disputes, and aquifer storage and recovery.

This program will consolidate current activities such as the USGS streamgaging network, National Groundwater Monitoring Network, flood inundation mapping, and storm surge monitoring. It incorporates the groundwater and streamflow monitoring activities of the Cooperative Water Program, the National Streamflow Information Program, Groundwater Resources Program, and some smaller elements of the Hydrologic Networks and Analysis and Hydrologic Research and Development Programs. The program will also be responsible for the support of information management functions that are vital to the dissemination of groundwater and streamflow observational data, and for the support of research to enhance monitoring activities.

$000 Water Resources Mission Area	Groundwater and Streamflow Information Program		
	2014 Actual	2015 Enacted	2016 Request
Groundwater Resources Program	745	3,703	4,720
National Water Quality Assessment Program	229	229	229
Hydrologic Research & Development Program	1,150	2,351	2,280
National Streamflow Information Program	32,233	33,440	35,425
Hydrologic Networks & Analysis Program	712	185	184
Cooperative Water Program	31,000	29,799	30,695

National Water Quality Program

The National Water Quality Program will encompass the Water Resources Mission Area's objectives through water-quality monitoring, assessment, and research activities. Specifically, the National Water Quality Program will provide data, information and understanding to: (1) Assess the current quality of the Nation's freshwater resources and how it is changing over time; (2) Explain how human activities and natural factors, such as land use, water use and climate change are affecting the quality of surface water and groundwater; (3) Determine the relative effects, mechanisms of activity, and management implications of multiple stressors in aquatic ecosystems; and (4) Predict the effects of human activities, climate change, and management strategies on future water quality and ecosystem condition.

This program will include the core water-quality monitoring , assessment, and research activities of the former National Water Quality Assessment Program (NAWQA), the National Stream Quality Accounting Network (NASQAN), the Hydrologic Benchmark Network, National Monitoring Network for U.S. Coastal Waters and Tributaries, National Atmospheric Deposition Network, Urban Waters, Cooperative Water Program, Hydrologic Research and Development Program, and the Hydrologic Networks and Analysis Program.

$000 Water Resources Mission Area	National Water Quality Program		
	2014 Actual	2015 Enacted	2016 Request
National Water Quality Assessment Program	58,630	59,230	61,399
Hydrologic Research & Development Program	4,420	3,888	4,646
Hydrologic Networks & Analysis Program	15,644	14,508	12,574
Cooperative Water Program	17,474	16,515	17,468

Water Resources Research Act (WRRA) Program

The WRRA Program provides an institutional mechanism for promoting State, tribal, regional, and national coordination of water resources research, training, and information and technology transfer. With its matching requirements, the program is also a key mechanism for promoting State investments in research and training. The Water Institutes have developed a constituency and a program that far exceeds that supported by their direct Federal appropriations. In 2014 and 2015, the WRRA Program is developing more-rigorous oversight to ensure that Federal investments at each of the Institutes effectively and consistently maximize national science goals and leverage all available resources, particularly in the areas of water availability, quality, and climate change. In 2016, the Water Resources Mission Area will work through the WRRA Program to ensure that activities funded by this Program at the Institutes are more closely aligned with the priority actions, goals, and objectives outlined in the Water Science Strategy, published in Circular 1383-G.

$000 Water Resources Mission Area	Water Resources Research Act Program		
	2014 Actual	2015 Enacted	2016 Request
Water Resources Research Act Program	6,500	6,500	6,500

Energy and Minerals, and Environmental Health

In 2016, the USGS proposes the following changes for the Energy, Minerals and Environmental (EMEH) budget activity and the four subactivities within it. The changes are budget neutral. There would now be two subactivities under EMEH: Mineral and Energy Resources; and Environmental Health. Under the Mineral and Energy Resources subactivity, there would be two Program Elements: Mineral Resources; Energy Resources. Under the Environmental Health subactivity, there would be two Program Elements: Contaminant Biology; Toxic Substances Hydrology.

New Budget Activities $000	2014 Actual	2015 Enacted	2016 Budget Request	Change from 2015 Enacted	% Change from 2015 Enacted
Energy and Minerals, and Environmental Health					
Mineral and Energy Resources					
Energy Resources Program	25,970	24,895	28,068	3,173	13%
Mineral Resources Program	45,931	45,931	47,717	1,786	4%
Total Mineral and Energy Resources	*71,901*	*70,826*	*75,785*	*4,959*	*7%*
Environmental Health					
Contaminant Biology Program	9,647	10,197	12,070	1,873	18%
Toxic Substance Hydrology Program	9,967	11,248	15,447	4,199	37%
Total Environmental Health	*19,614*	*21,445*	*27,517*	*6,072*	*28%*
Total	**91,515**	**92,271**	**103,302**	**11,031**	**12%**

Former Budget Activities $000	2014 Actual	2015 Enacted	2016 Budget Request	Change from 2015 Enacted	% Change from 2015 Enacted
Energy, Minerals, and Environmental Health					
Energy Resources Program	25,970	24,895	28,068	3,173	13%
Mineral Resources Program	45,931	45,931	47,717	1,786	4%
Contaminant Biology Program	9,647	10,197	12,070	1,873	18%
Toxic Substance Hydrology Program	9,967	11,248	15,447	4,199	37%
Total	**91,515**	**92,271**	**103,302**	**11,031**	**12%**

Internal Transfer

USGS Internal Transfers			
Subactivity	**Internal Transfer**	**2016 Program Change Amount**	**FTE Changes**
Internal Transfer: Increase		**2,365**	**19**
Environments Program	Transfer from National Water Quality	2,191	18
Coastal & Marine Geology	Transfer from Water Availability and Use Science	174	1
Internal Transfer: Decrease		**-2,365**	**-19**
National Water Quality	Transfer to Environments Program	-2,191	-18
Water Availability & Use Science	Transfer to Coastal and Marine Geology	-174	-1
Internal Transfer Total		**0**	**0**

Ecosystems

Environments **(+$2,191,000/+18 FTE)**

The Environments program receives funding annually from the Water Resources Mission Area to fund priority ecosystems activities at sites such as the Florida Everglades, Chesapeake Bay, and the California Bay Delta. As proposed, this internal transfer will relieve the Water Resources Mission Area from continuing to reallocate this funding each year to the Environments Program. Instead, the Environments Program will receive the funding directly in their budget line item. The Environments Program uses this funding (along with other funds) to provide integrated science support to better understand the interactive nature of resources and the environment. This integrated science is aimed at improving the understanding of the rates, causes, and consequences of natural and human-induced processes that shape and change the landscape over time, and to provide comprehensive information needed to understand the environmental, resource, and economic consequences of landscape change.

Natural Hazards

Coastal and Marine Geology **(+$174,000/+1 FTE)**

The Coastal and Marine Geology Program receives funding annually from the Water Resources Mission Area to fund land subsidence activities, primarily in Louisiana. This internal transfer will relieve the Water Resources Mission Area from continuing to reallocate this funding each year to Coastal and Marine Geology Program. Instead, the Environments Program will receive the funding directly in their budget line item.

Water Resources **(-$2,365,000/-19 FTE)**

Water Availability and Use Program	(-$174,000/-1 FTE)
National Water Quality Program	(-$2,191,000/-18 FTE)

In order to more closely align work in the Mission Areas, Ecosystems would receive $2.2 million and Natural Hazards would receive $0.2 million from the Water Resources Mission Area to support Ecosystems and Natural Hazards research goals that are mentioned above. This internal transfer will relieve the Water Resources Mission Area from continuing to reallocate this funding each year to the Environments and Coastal Marine Geology programs. Instead, the Environments and Coastal Marine Geology programs will receive the funding directly in their budget line item.

Program Changes

Program Changes

	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Water Science for the 21st Century	**14,521**	**26**	C-3
WaterSMART	14,584	29	C-4
Science to Support Sustainable Water Use	-63	-3	C-14
Landscape Understanding	**15,569**	**47**	C-17
Critical Landscapes	6,650	24	C-18
Invasive and Declining Species	3,810	10	C-25
Coastal Resilience and Landscapes	5,109	13	C-28
Natural Hazards Science	**6,618**	**10**	C-33
Natural Hazards Science for Disaster Response	6,618	10	C-34
Foundations for Land Management	**37,826**	**25**	C-43
Landsat Ground System	24,300	0	C-44
Ecosystem Services	1,750	5	C-45
Big Earth Data	1,100	0	C-48
Landsat Science Products for Climate and Natural Resources Assessments	4,000	2	C-49
National Civil Applications Program	-1,000	-5	C-49
3D Elevation Program	3,709	3	C-50
Great Lakes Fisheries Assessments	250	0	C-52
Enhanced Cooperative Activities and Urban Waters	717	5	C-53
Outer Continental Shelf (OCS) Ecosystems Decisions	300	2	C-54
Enhanced Support and Scientists for Tomorrow	2,000	9	C-54
Emerging Contaminants and Chemical Mixtures	700	4	C-55
Climate Resilience	**32,018**	**36**	C-57
Carbon Sequestration	8,700	21	C-58
Adaptation and Resilience	6,818	13	C-60
Community Resilience and Partnerships	16,500	2	C-62
Energy and Minerals	**9,548**	**44**	C-67
All-of-the-Above Energy	8,549	30	C-68
Critical Minerals	999	14	C-75
Science Infrastructure	**21,131**	**19**	C-77
Infrastructure Capacity to Support the Science Mission	18,931	16	C-78
Science Coordination	500	1	C-82
Engaging the Next Generation: Building a 21st Centrury Workforce	1,700	2	C-83
Grand Total	**137,231**	**207**	

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Water Science for the 21st Century

Water Science for the 21st Century ($ in Thousands)	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
WaterSMART	**14,584**	**29**	C-4
Water Use Information	**3,000**	**5**	C-5
Water Availability and Use Science Program	3,000	5	C-5
Ecological Flows	**2,500**	**4**	C-6
Fisheries Program	2,500	4	C-6
Streamflow Information	**1,328**	**0**	C-7
Groundwater and Streamflow Information Program	928	0	C-7
Water Availability and Use Science Program	400	0	C-7
Water Use Research	**1,000**	**0**	C-8
Water Availability and Use Science Program	1,000	0	C-8
Advancing the National Groundwater Monitoring Network	**1,000**	**1**	C-9
Groundwater and Streamflow Information Program	1,000	1	C-9
National Hydrography Database	**1,000**	**3**	C-9
National Geospatial Program	1,000	3	C-9
Remote Sensing	**800**	**3**	C-10
Land Remote Sensing	400	1	C-10
Land Change Science	400	2	C-10
National Hydrologic Model	**750**	**1**	C-11
Water Availability and Use Science Program	750	1	C-11
Science to Support Drought	**3,206**	**12**	C-11
Environments Program	300	2	C-12
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	1,030	2	C-12
Climate Research & Development	1,125	5	C-12
Land Remote Sensing	250	1	C-13
Water Availability and Use Science Program	301	2	C-13
Science Synthesis, Analysis and Research Program	200	0	C-14
Science to Support Sustainable Water Use	**-63**	**-3**	C-14
Cycle 3 National Water Quality Assessment	**881**	**0**	C-14
National Water Quality Program	881	0	C-14
HR&D Monitoring and Assessments	**-1,000**	**-4**	C-15
Water Availability and Use Science Program	-550	-3	C-15
Groundwater and Streamflow Information Program	-100	0	C-15
National Water Quality Program	-350	-1	C-15
Model Development and Research	**-444**	**-2**	C-15
Water Availability and Use Science Program	-444	-2	C-15
Tribes	**500**	**3**	C-16
Groundwater and Streamflow Information Program	500	3	C-16
Grand Total	**14,521**	**26**	

Justification of 2016 Program Changes (+$14,521,000/+26 FTE)

WaterSMART (+$14,584,000/+29 FTE)
Science to Support Sustainable Water Use (-$63,000/-3 FTE)

Overview

Water is an essential ingredient for healthy communities, economies, and the ecosystems of the Nation. In 2016, the USGS is requesting an additional $14.5 million to expand, enhance, and initiate science activities involving the quantity and quality of water used by or needed for competing water uses. This is especially important at a time when ensuring sustainable water supplies is increasingly challenged by changes in the frequency and magnitude of extreme hydrologic events, such as floods and droughts,

creating new uncertainty for water managers. Efforts will continue and expand under Interior's WaterSMART initiative. USGS scientists will provide water managers with science, monitoring, assessments and tools to understand, address, and plan for competing demands for water. The primary focus will continue to be on developing a National Water Census, better understanding of water budgets, and supporting sustainable and environmentally sound water management. Expertise across multiple disciplines enables a broader focus to provide water resource, ecosystem, and land use managers the decision-support tools to make informed decisions.

WaterSMART (+$14,584,000/+29 FTE)

Water Use Information	(+$3,000,000/+5 FTE)
Ecological Flows	(+$2,500,000/+4 FTE)
Streamflow Information	(+$1,328,000/0 FTE)
Water Use Research	(+$1,000,000/0 FTE)
Advancing the National Groundwater Monitoring Network	(+$1,000,000/+1 FTE)
National Hydrography Database	(+$1,000,000/+3 FTE)
Remote Sensing	(+$800,000/+3 FTE)
National Hydrologic Model	(+$750,000/+1 FTE)
Science to Support Drought	(+$3,206,000/+12 FTE)

Overview

Meeting the water resource needs of the Nation is an increasing challenge in the face of rapidly changing drivers of water availability, such as climate change. At a time when ensuring sustainable water supplies is more important than ever, change in the frequency and magnitude of extreme hydrologic events, such as floods and droughts, are creating uncertainty for water managers. As competition for water resources grows for irrigation of crops, cities and communities, energy production, and the environment, so does the need for information and tools to aid water and natural resource managers. WaterSMART is a Department of the Interior (Interior) initiative that leverages and directs existing expertise and resources within the USGS and the Bureau of Reclamation (Reclamation) toward addressing complex, national- and regional-scale water challenges. The USGS is providing the science to help water managers understand and address competing demands for water. The primary focus of this initiative includes developing a National Water Census, better understanding of water budgets, and supporting sustainable and environmentally sound water management. Leveraging expertise across multiple disciplines enables a broader focus to address these challenging issues in a time of growing competition for water resources. The USGS possesses the skills and foundational resources to provide water resource, ecosystem, and land use managers the decision-support tools to make informed decisions. The goal of this effort is to improve the data and understanding associated with groundwater, surface water, human water use, and the ways in which they influence water availability, and to develop tools that will allow managers to apply the new understanding and data. The USGS expertise in understanding hydrologic cycle effects on water, human water use, and the ways in which water quality and quantity affect the natural environment is critical to addressing this issue. The Nation will be well served through this effort, by gaining the ability to balance water resource sustainability through consideration of water quantity, quality, and uses, including ecological uses.

Program Performance

Water Use Information **(+$3,000,000/+5 FTE)**

Water Availability and Use Science Program (+$3,000,000/+5 FTE)

Since 1950, the USGS has been the primary Federal agency responsible for providing a comprehensive understanding of water use across the Nation, with consistent reporting every five years through the USGS series of circulars: Estimated Use of Water in the United States. As required under the SECURE Water Act (P.L. 111-11), and the President's Climate Action Plan, the USGS is working to expand its efforts and provide comprehensive, high-resolution water use information (on an annual basis and at a location) that will support a host of decision-support systems. This high-resolution water use information will allow resource modelers and managers to understand the influence that human water use has on the hydrologic cycle, the degree to which human consumptive uses influence the sustainability of water supplies, and allows comparison of human water demands to the sustainability of environmental water needs. The USGS has already begun work under the National Science and Technology Council's (NSTC) Committee on the Environment, Natural Resources, and Sustainability to coordinate activities with other Federal agencies and State agencies to scope the effort for providing this high-resolution water use information. The USGS is coordinating an effort with the Bureau of Reclamation, the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (USACE), and the Department of Energy (DOE) to improve their ability to feed base data into the water use databases.

The 2016 requested increase would allow the USGS to participate in a new multi-agency, Open Water Data Initiative that will integrate water information that is fragmented among multiple agencies into a national water data framework on a geospatial platform, as a placebased database. The Open Water Data Initiative will leverage existing partnerships and infrastructure to allow for greater data accessibility and better tools and solution development.

The requested increase would also allow the Water Resources Mission Area to continue to provide grants to State Water Resource Agencies to improve their ability to provide the base data at the necessary resolution for effective decisionmaking. Comprehensive water use information would be provided on an annual and ongoing basis for the following sectors of water use: irrigation, public water supplies, thermoelectric cooling water, industrial self-supplied water, and aquaculture. In addition, water use would be estimated for the mining, livestock, and self-supplied domestic water use sectors. The data would be formatted to allow easy input of water use to the National Hydrologic Model, as well as other models utilized by the USGS and others. The USGS would coordinate these activities with other Federal agency efforts, provide grants to and coordination with State Water Resources Agencies on their data delivery, and maintenance of the comprehensive Site-specific Water Use Data System and Aggregate Water-Use Data System databases. Finally, this funding would support periodic comprehensive analysis of the data to report out on water use trends and provide national water-use indicator analysis, and maps of water stress indicators.

Ecological Flows **(+$2,500,000/+4 FTE)**

Fisheries (+$2,500,000/+4 FTE)

The delivery of water at the correct time, quantity, and quality is critical to society both economically and ecologically. Recovery and restoration of aquatic ecosystems are dependent on the proper balance among societal and ecological needs. Healthy watersheds and sustainable, secure water supplies are challenged by climate change, and record drought conditions. With increased demand for freshwater use for domestic supply, agriculture, manufacturing, and energy production, there is a growing need to understand and quantify water needs. Moreover, there is a need to understand and quantify the associated societal and economic values in order to allow water managers to evaluate tradeoffs in monetary and non-monetary costs of water allocation decisions. This type of information, coupled with an understanding of how flow variability is related to ecological response, is utilized by water management authorities to establish flow criteria (often-minimum flow criteria), and ultimately relate them to allocation decisions for water withdrawals from streams, rivers and basins. Scientific underpinnings and advancements are crucial for advancing sustainability of healthy watersheds and water supply.

Decisions made every day by Federal, State and local managers affect the quantity, quality, and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems. With increased demand for consumptive freshwater use for domestic supply, agriculture, manufacturing, energy production, and ecological sustainability, there is a growing need to develop Decision Support Systems (DSS) that have the capacity to provide a diverse set of management options to water regulators and stakeholders including water for human use, including: maintenance of economically and ecologically important species; minimizing adverse impacts and vulnerabilities in floodplains or flood-prone areas; and protecting and restoring the functions of natural systems. These DSS tools enable managers to factor in the full range of values—both monetary and non-monetary—in decisions that attempt to balance human and ecosystem needs.

Although many useful DSS tools have been developed to help decisionmakers enhance the sustainability of water supplies, they are often not transferable to other basins and systems. The proliferation of these site-specific tools makes it difficult to conduct analyses at the regional and national levels to inform decisionmaking. In addition, because they often do not explicitly consider public benefits in terms of economic, environmental and social goals, including monetary and non-monetary benefits, they limit the range of resolution options of decisionmakers. Broadening existing decision support tools to other basins and systems will provide a more comprehensive understanding of future water needs and tradeoffs associated with various management options. This will reduce uncertainty in water availability estimates and optimize the information water managers use to make important water allocation decisions.

The USGS conducts research in collaboration with Federal agencies (Bureau of Reclamation [BOR], National Oceanic and Atmospheric Administration [NOAA], USACE, and the U.S. Forest Service [USFS]), State, academic, and private partners. This research supports better incorporation of consistent, broadly applicable DSS into national water management decisions:

1. Adapt existing ecological flow DSS to other United States aquatic systems. DSS's are important management tools to help water managers and stakeholders understand tradeoffs and risks for meeting water supply needs. Building off existing DSS platforms, such as the recently completed and highly successful Delaware River Environmental Flow DSS, to develop a broadly applicable "generic" suite of DSS tools, is an essential step in enhancing capacity for water regulators across the United States.
2. Use lidar, a remote sensing technology, to derive the detailed bathymetric coverages needed to assess the changes in riverine habitat that affect ecological flow requirements. There is a need to develop and more broadly apply lidar data for support of ecological flow analyses in United States river basins. This emerging technology shows great promise for providing the data necessary to develop the habitat suitability measures needed for assessing changes in economically and ecologically important aquatic species as part of a fully integrated DSS. Ideally, a fully integrated DSS will enable water managers to simultaneously evaluate water allocation scenarios while considering all facets of the water budget and facilitate more informed decisionmaking about living resources, habitat, and other values.
3. Incorporate DSS into existing and ongoing water availability efforts (e.g., Principles and Requirements for Federal Investments in Water Resources, National Water Census Focus Area Studies) and support the further collection of biological components. DSS tools assist with understanding the quantitative linkages between changes in flow process and response of aquatic organisms, riparian vegetation, and other values in order to provide water regulators with diverse water allocation scenarios. However, there is an imminent need to improve this linkage through the collection of ecological data at a space and time that allows for better quantification and modeling of biological response and to include other values in DSS model components. In addition, monetary and nonmonetary values should be incorporated into these tools to allow decisionmakers to assess the full range of tradeoffs associated with water allocation decisions.

In 2016, and beyond, the Ecosystems and Water Resources Mission areas will continue to collaborate on research efforts in the Delaware, Colorado, and Apalachicola, Chattahoochee and Flint (ACF) River watersheds in addition to taking lessons learned from these watersheds to an additional three watersheds, which will be identified through a request for proposal (RFP) process involving all USGS Mission Areas currently collaborating in the National Water Census.

Streamflow Information **(+$1,328,000/0 FTE)**

Groundwater and Streamflow Information Program	(+$928,000/0 FTE)
Water Availability and Use Science Program	(+$400,000/0 FTE)

Streamflow information is required for water-resources management, and changing streamflow conditions require continuity of information for flood and drought response and routine water allocations. This activity would have three elements:

1. Increase the number of streamgages: Approximately 35 streamgage sites would be supported within the Groundwater and Streamflow Information Program. These could include reactivation

of discontinued sites, construction of new sites, and support of sites currently supported through other, less stable funding sources.

2. Estimate streamflow in remote areas using remote sensing: In remote regions of the United States, such as Alaska, little streamflow information is available, so methods for estimating streamflow in ungaged basins are not applicable. Direct gaging of Alaska rivers poses substantial logistical difficulties. Remote sensing assets may be more viable for estimating streamflow than in the lower 48 States due to increased frequencies of over flight by polar orbiting satellites. The proposed activity would test the potential of estimating streamflow in the Alaska frontier during open flow seasons. The streamflow estimates derived from remote sensing would be compared to both observed and calculated streamflow estimates. This will be implemented through the Groundwater and Streamflow Information Program.
3. Estimate monthly streamflow statistics: A goal of the National Water Census effort is to provide estimates of streamflow statistics throughout the Nation. The USGS StreamSTATS decision-support tool allows the USGS and partners to develop these estimates. StreamSTATS would be implemented in three additional States, and improved methods for proving the estimates would continue to be investigated. This will be implemented through the Water Availability and Use Science Program.

Water Use Research **(+$1,000,000/0 FTE)**

Water Availability and Use Science Program (+$1,000,000/0 FTE)

Water use information that identifies the impacts of human water withdrawals and return-flows is critical for the National Water Census's water budget analysis. This information, which is mostly collected at State, tribal, regional, and local governmental levels, must be obtained on a site-specific scale in order to be fully useful in the National Water Census analyses. The Water Availability and Use Science Program would work directly with State, tribal, regional, and local cooperators to match this funding and make maximum use of their water use datasets in the water availability and use assessment. Directed work is required to develop better methods of sampling, estimating, aggregating, and presenting water use data. This includes research into new methods that use remote sensing and spatial datasets in water use estimation. The research and networks and analysis functions of the USGS would work together to advance the development of those methods for use within the WaterSMART initiative. The USGS would integrate this information with decision-support tools that facilitate use of that information in a manner that is relevant to water resource management decisionmaking.

USGS monitoring, assessments, and research would continue and expand related to WaterSMART and impacts on water use. Additional focus will be placed on tracking site-specific, public supply and other water use information; developing consumptive use measurements and methodology (particularly associated with irrigated agriculture); assessing watershed water budgets (including developing estimates for streamflow at ungaged sites for more accurate water budgets); developing water use/budget models to track long-term patterns in groundwater and surface water flow; and advancing evapotranspiration measurements and assessment techniques.

Advancing the National Groundwater Monitoring Network **(+$1,000,000/+1 FTE)**

Groundwater and Streamflow Information Program (+$1,000,000/+1 FTE)

Current USGS water-level networks, such as the National Groundwater Monitoring Network, do not provide adequate space and time monitoring for all the Nation's major aquifers, which is critical information for determining water availability. To address this national need, a framework was developed in 2009 for a National Groundwater Monitoring Network (NGWMN) in response to the SECURE Water Act (P.L. 111-11) Section 9507(b) to provide a systematic groundwater-monitoring program for each aquifer system in the United States. To date, the Advisory Committee on Water Information (ACWI) Subcommittee on Groundwater (SOGW), through a successful pilot program and a pilot information portal developed by the USGS Groundwater Resources Program, demonstrated that a collaborative NGWMN can be successfully implemented by taking advantage of existing monitoring done by Federal, State, tribal and local agencies *(http://acwi.gov/sogw/*).

The Water Resources Mission Area would enhance research activities to improve drought forecasting. This activity is consistent with the Committee on the Environment, Natural Resources, and Sustainability focus on improving groundwater data and understanding. Groundwater and surface water availability changes will be evaluated by improving internal and external coordination and enhancing monitoring activities and data delivery systems to create a stronger link among the surface water and groundwater monitoring networks of the USGS, groundwater networks of State agencies, and the soil moisture network of Natural Resources Conservation Service (NRCS). Links would be improved between the well-coordinated ground-based monitoring networks and remote-sensing products. Drought creates an increased demand for groundwater resources, and land subsidence from the increased groundwater withdrawals is a critical issue in some hydrogeologic settings. Land subsidence work would be enhanced to help characterize the potential impacts of drought on infrastructure.

National Hydrography Database **(+$1,000,000/+3 FTE)**

National Geospatial Program **(+**$1,000,000/+3 FTE)

The USGS has been working since 1998, through the National Geospatial Program (NGP), the former National Water Quality Assessment (NAWQA) program and StreamStats, to create and improve the National Hydrography Dataset (NHD). Along with the Watershed Boundary Dataset, the NHD is used to portray surface water on The National Map. The NHD represents the drainage network with surface water features such as rivers, streams, canals, lakes, ponds, coastline, dams, and streamgages. Efficiently tracking water use and the relationship between manmade diversions and stream flow, requires that the points of withdrawal and discharge be mapped within the stream network. Currently, hydrography datasets of differing functionality and scales are used by agencies including the USGS, the Environmental Protection Agency, the U.S. Forest Service, and the Bureau of Land Management. The water resource community, including Federal, State, tribal, and local water resource managers; and private and non-profit organizations would benefit from using a single, scalable hydrographic referencing system with robust functionalities.

With these funds, the NGP will complete national NHDPlus high-resolution (1:24,000 scale) coverage for the conterminous 48 States, Hawaii, and Puerto Rico. This achievement will create a revolutionary integrated elevation-hydrography dataset for water resource managers throughout the Nation. Future lidar-derived integrated elevation-hydrography data will fit into the same structure and use the same utilities. This full integration of elevation and hydrography provides the potential to radically simplify hydrography data and streamline the user experience, application development, and stewardship of the data. Taking this step now positions the USGS to be able to fully utilize lidar data as they become available through the 3D Elevation Program (3DEP). It will also support the Water Census and enable an initial step in delivering the Open Water Data Initiative. Developing a single, scalable hydrographic referencing system will integrate currently fragmented water information into a connected, national water data framework to underpin innovation, modeling, data sharing, and solution development.

Remote Sensing **(+$800,000/+3 FTE)**

Land Remote Sensing	(+$400,000/+1 FTE)
Land Change Science	(+$400,000/+2 FTE)

The National Water Census already benefits from the use of remote sensing data and analysis, including Landsat data. In 2016, the USGS would expand work across its land use and water programs to support additional aspects of the National Water Census. The National Water Census is at a place in its development to access operational Landsat products, generated as frequently as every eight days. Several new Landsat-based science products (including estimates of surface water extent) are at the stage of development to integrate with the National Water Census.

In the United States, good information on the amount of water in large storage features such as reservoirs and lakes is available. However there is a significant gap is identifying and quantifying water storage in smaller storage features. These water storage features influence the flow characteristics of streams in each watershed. Understanding and reporting on these features could provide benefit for drought status monitoring, understanding climate variability, and streamflow estimation, particularly in areas without streamgages. Moreover, information on changes in surface water storage is essential in order to accurately estimate the total amount of water in a basin—a central need for the National Water Census.

The USGS proposes to locate surface water features that have either been built or naturally store water (i.e., act like reservoirs). Given estimates of over three million constructed impoundments in the country, ranging from numerous small farm ponds up to large monitored reservoirs, remote sensing methods are the only feasible method for improving estimates of the total amount of water in a watershed.

The proposal would develop these estimates in a nationally consistent manner, and track changes in the number and size of these surface features within a year and across decades. Many of these water features are unknown because they are temporary, only storing water after precipitation events. Detection, documentation and monitoring of these features is only feasible through the use of a remote sensing system such as Landsat, which frequently and routinely images the land surface over long periods of time.

In a watershed such as the Apalachicola Chattahoochee, and Flint (ACF) such monitoring would provide an objective and systematic methodology for comprehensively assessing the state of the watershed, allowing multiple political entities to coordinate water usage and management.

National Hydrologic Model **(+$750,000/+1 FTE)**

Water Availability and Use Science Program (+$750,000/+1 FTE)

The Committee on the Environment, Natural Resources, and Sustainability has recognized the need for a National Hydrologic Modeling Framework to advance understanding and forecasting of the water budget, to effectively manage water resources, and to adapt to a changing climate. The USGS currently has a national scale hydrologic model that addresses the major components of the water budget, but human water use is not addressed explicitly. Moreover, information needed to operate the model must be obtained in a labor-intensive method. There is a need to assemble community modeling resources (i.e., datasets, models, use cases) to economize and enhance model development and verification activities across the community. Model development assumes continued community use of legacy models and datasets rather than proposing a new model framework. Such an activity would improve and modernize access to resources that support development, verification, or model application for specific decision situations.

This work, conducted in collaboration with other Federal agencies with major modeling and data generation activities would accelerate collaborative development of a nationwide hydrologic model that accounts for all aspects of the water budget. Initially, the USGS would work to incorporate remote sensing, including lidar and geophysical data, to refine landscape-scale topography, landcover, geologic framework, soil moisture, evapotranspiration estimates, and changes in depression storage. The USGS would begin steps to improve linkages between surface and groundwater hydrologic models by accommodating variable grid sizes and time steps, nesting existing fine-scale models within coarse-scale regional models. Finally, initial steps would be taken to refine operation of surface water models in sub-daily mode to better forecast flood response in smaller basins.

Science to Support Drought **(+$3,206,000/+12 FTE)**

Responding to drought and managing limited water resources are primary drivers for many land and water management agencies. Given the persistent drought in multiple regions of the United States, the USGS proposes to quantify streamflow for all areas of the country, make precipitation data readily available, and determine groundwater availability under drought conditions. Providing access to these data will allow managers to determine impacts of drought on ecological systems. The USGS will develop actionable science approaches, by convening regionally based working groups of decisionmakers and natural resource managers to develop coordinated adaptive management plans for the complex consequences of severe and prolonged drought. The funding requested for this work would provide tools for fish and wildlife managers as well as water resource managers.

Environments Program (+$300,000/+2 FTE)

More frequent and prolonged drought will increase the need to support investigations focused on the effects of extended drought on long-term population viability and habitat as well as terrestrial freshwater quality. The Environments Program would use the requested funding increase to support regional investigations of how drought interacts with other environmental stressors such as invasive vegetation and wildfires to affect landscape composition, structure, and function. Information derived from these investigations will be provided to resource managers that can then evaluate the tradeoffs between land management strategies and determine which strategies will be most effective for managing their resources.

National Climate Change and Wildlife Science Center/
DOI Climate Science Centers (CSCs) (+$1,030,000/+2 FTE)

Understanding thresholds and tipping points caused by droughts is critical in providing managers with early action options. The National Water Census Data Portal serves information on streamflow, precipitation, and water use that can be utilized by the National Climate Change and Wildlife Science Center (NCCWSC)/DOI Climate Science Centers (CSCs) Program to provide the foundational data needed to build decision support tools. The NCCWSC would use the requested funding increase to continue to develop a science-based decision process for understanding and managing the impacts of drought on various parts of the Central and Western United States, including California. Much research is available on the effects of drought on human systems, notably agriculture, but the ecological effects are not as well studied. The program proposes to bring a diverse group of stakeholders together to gain a science-based, integrative understanding of drought impacts to their resource management responsibilities, and of their potential adaptive management responses. The USGS's goal is to use one or two drought stricken regions as examples to understand the impacts and then develop a decisionmaking process for managing limited water supplies in places like central California and the South Central United States. The USGS would develop working groups in places impacted by drought, consisting of USGS scientists, partners, and regional stakeholder networks to identify the science needs. Scientists attached to these working groups will develop models that integrate the social and economic impacts from drought and the USGS will use the NCCWSC/CSC Program's visualization facility (located in the Fort Collins Science Center) to allow the working groups to analyze scenarios using different decision points. In the requested increase, the program would expand the actionable science approach to other regions of the country that are prone to drought. The program would integrate results from climate driven drought projection models into models of ecological flow and wildlife impact to understand which areas of the country are more vulnerable to drought impacts. By focusing on the ecological impacts of drought, this project complements ongoing activities focused on water availability/supply and the agricultural and municipal effects of drought such as those under the National Integrated Drought Information Systems, U.S. Bureau of Reclamation basin studies, and other partners' efforts.

Climate Research and Development (+$1,125,000/+5 FTE)

The Climate Research and Development (R&D) Program would use the requested funding increase to document long-term and medium-term patterns of drought and water availability in the Western and

Southeastern United States. Understanding patterns of drought is critical to develop sustainable plans for use of limited water resources by management agencies. These efforts would focus on synthesizing long-term patterns of United States hydroclimate in the two regions, including amount of precipitation, seasonality of precipitation (rain vs. snow), and variability in water availability over annual, decadal, and longer time scales. This research would provide a context to assess the magnitude and regional impacts of current and future droughts, and provide information on how ecosystems of the Western and Southeastern United States have responded to past intervals of drought. These studies would provide resource managers with real-world results that could be used to test results from a range of climate and ecosystem models.

In the Pacific Northwest and Alaska, water availability and water quality also are influenced by glacier dynamics. Increased funding would be used to expand ongoing research on alpine glaciers. Development of new and improved techniques to measure changes in the amount of water contained in alpine glaciers would improve the understanding of long-term patterns of glacier change and their influence on water availability and the transport of carbon and nutrients to streams, estuaries, and oceans. Such evidence would provide data needed by resource managers to better forecast changes in streamflow and ecosystem function in watersheds fed by alpine glaciers. The data and information collected by the Climate R&D Program can be compared to the current data that is collected and served through the National Water Census. This type of comparison would allow resource managers to use past examples to help understand current conditions in their area.

Land Remote Sensing (+$250,000/+1 FTE)

The Land Remote Sensing (LRS) program would use the requested increase to work with the NCCWSC and the North Central CSC to investigate the relationship between drought and climate change on wildlife populations and their food sources. Drought-related indices and land cover would be used to model and predict how drought and climate change are impacting the phenology of animal migration and the forage quality of Western habitats. Current land change datasets and drought products will be evaluated for their adequacy to support management decisions for wide-ranging ungulate (e.g., Mule deer, Big Horn Sheep) populations and key habitats. The LRS program, along with the NCCWSC and the North Central CSC, would collaborate to identify gaps in remote sensing data, collect new data for model validation, and recommend new methodologies to meet the needs of scientists and decisionmakers in the conservation and land management communities. VegDRI is an operational drought model and map created weekly. The information is used by numerous organizations for drought mitigation decision supports. This information will be integrated with the evapotranspiration outputs that the National Water Census is already delivering to the public via the National Water Census Data Portal. The use of these and related capabilities would be extended into the habitat modeling community.

Water Availability and Use Science Program (+$301,000/+2 FTE)

The Water Availability and Use Science Program would use the requested increase to improve water data and forecasting for drought. The program would create actionable, science-based information and tools as called for under the President's National Drought Resilience Partnership (NDRP). The NRDP's goal is to make it easier to access Federal drought resources by linking information such as monitoring, forecasts,

outlooks, and early warnings with longer-term drought resilience strategies in critical sectors such as agriculture, municipal water systems, energy, recreation, tourism and manufacturing. More accurate information about the timing and duration of droughts can enable States, tribes, counties and cities to plan more effectively and reduce drought impacts. In addition, the program would enhance research activities to improve drought forecasting. Groundwater and surface water availability changes would be evaluated by improving internal and external coordination and enhancing monitoring activities and data delivery systems to create a stronger link among the ground-based surface water and groundwater monitoring networks of the USGS, groundwater networks of State agencies and the soil moisture network of Natural Resource Conservation Service (NRCS). Links would then be improved between the well-coordinated ground-based monitoring networks and USGS remote sensing products. These data and information would be served through the National Water Census Data Portal. Drought creates an increased demand for groundwater resources, and land subsidence from increased groundwater withdrawals is a critical issue in some hydrogeologic settings. Land subsidence work would be enhanced to help characterize the potential impacts of drought on infrastructure.

Science Synthesis, Analysis, and Research (+$200,000/0 FTE)

The Science Synthesis, Analysis, and Research (SSAR) program would use the requested increase to build on existing capabilities in gap analysis and collaborations with the Land Change Science (LCS) Program to provide species modeling for specific habitats. These outputs will improve the USGS support to ecosystem conservation planners by providing maps and analyses of species and habitats of critical concern for drought effects and areas most promising for mitigation actions.

Science to Support Sustainable Water Use (-$63,000/-3 FTE)

Cycle 3 National Water Quality Assessment (+$881,000/0 FTE)
HR&D Monitoring and Assessments (-$1,000,000/-4 FTE)
Model Development and Research (-$444,000/-2 FTE)
Tribes (+$500,000/+3 FTE)

Program Performance

Cycle 3 National Water Quality Assessment (+$881,000/0 FTE)

National Water Quality Program –
Support National Water Quality Assessment Cycle 3 (+$1,881,000/+4 FTE)
National Water Quality Program – Water Quality Monitoring (-$1,000,000/-4 FTE)

The National Water Quality Program's Cycle 3 (2013-2023) would be a leading source of scientific information for the development of effective policies and management strategies to protect and improve water quality for human and ecosystem needs. National Water Quality Assessment data, water-quality models, and scientific studies will characterize where, when, why, and how the Nation's water quality has changed, or is likely to change in the future, in response to human activities and natural factors. In 2016, the National Water Quality Program requests to reduce lower priority water quality monitoring to refocus

on supporting the National Water Quality Assessment Cycle 3 monitoring activities. The 2016 proposed funding increase will help the National Water Quality Program address priority aspects of the strategic science plan endorsed by the National Research Council and stakeholders such as the Advisory Committee on Water Information (http://water.usgs.gov/nawqa/pubs/fs-2013-3008/). Specifically, the resources will be used to:

- Work with Federal, State, and tribal partners to fill long-term water-quality monitoring gaps in critical watersheds and aquifers by leveraging available resources and collaborating with other programs to build an expanded and sustainable national network. Monitoring approaches will emphasize rapid feedback on changing water-quality conditions so that managers can identify emerging problems.
- Develop capability to provide annual Web-based reporting of the concentrations, loads, and trends of nutrients, sediment, and other contaminants in rivers flowing into important coastal estuaries to meet stakeholder needs for more-timely reporting of water-quality information.
- Develop forecasting and scenario-testing tools that will enable timely evaluation of current water-quality issues as well as the possible effects of future scenarios of changing climate, land use, and management practices by stakeholders.

HR&D Monitoring and Assessments **(-$1,000,000/-4 FTE)**

Water Availability and Use Science Program	(-$550,000/-3 FTE)
Groundwater and Streamflow Information Program	(-$100,000/0 FTE)
National Water Quality Program	(-$350,000/-1 FTE)

As resources are refocused on high-priority research areas such as the Puget Sound, water-related effects of unconventional oil and gas development, and methods for enhancing streamgaging, the Water Resources Mission Area proposes a $1 million redirection of funding towards these areas. The proposed redirection of funding would result in reduced efforts on development of methods to detect various human-use compounds in water. This would slow progress on data collection and publication of information products in specific areas related to contaminants, ecosystem restoration, and others.

Model Development and Research **(-$444,000/-2 FTE)**

Water Availability and Use Science Program	(-$444,000/-2 FTE)

The proposed change is reducing lower priority efforts within the Water Availability and Use Science Program to refocus on supporting National Water Census efforts. This would delay the advancement in groundwater model development to improve predictions of water availability and research to better understand the fate of contaminants in the environment.

Tribes **(+$500,000/+3 FTE)**

Groundwater and Streamflow Information Program (+$500,000/+3 FTE)

In 2016, the Groundwater and Streamflow Information Program is requesting an increase to build upon a 2015 investment to strengthen technical information needed to support water rights settlement work. Monitoring, assessments, and research would continue and expand work related to water availability issues on tribal lands in order to address such topics as water rights, water use, hydrologic conditions, and water-quality issues. The Groundwater and Streamflow Information Program would continue development of quantitative models of water budgets, including groundwater and surface-water interactions, that provide information on how human and natural factors, such as groundwater pumping and climate change, affect streamflows so that tribal river managers can develop effective strategies to maintain water supplies and restore critical habitats and healthy ecosystems. Building on an increase for tribal cooperators in 2014 and 2015, funding would be allocated in coordination with the Secretary's Indian Water Rights Office and other bureaus (including the Bureau of Indian Affairs and Reclamation) that support the Federal trust responsibility for water in Indian Country.

Landscape Understanding

Landscape Understanding ($ in Thousands)	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Critical Landscapes	**6,650**	**24**	C-18
The Changing Arctic	**4,200**	**16**	C-19
Environments Program	700	5	C-19
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	500	4	C-20
Land Remote Sensing	250	1	C-20
Coastal & Marine Geology	2,000	4	C-21
Water Availability and Use Science Program	750	2	C-22
Columbia River (Salmon)	**600**	**1**	C-22
Environments Program	150	0	C-22
Contaminant Biology	50	0	C-22
Toxic Substance Hydrology	50	1	C-22
National Geospatial Program	350	0	C-22
Puget Sound	**750**	**1**	C-23
Environments Program	200	0	C-23
National Water Quality Program	100	1	C-23
National Geospatial Program	450	0	C-23
Science for the Sage Steppe Landscape	**1,000**	**5**	C-24
Environments Program	1,000	5	C-24
Upper Mississippi River	**100**	**1**	C-25
National Water Quality Program	100	1	C-25
Invasive and Declining Species	**3,810**	**10**	C-25
Brown Tree Snakes - Detection and Control	**250**	**0**	C-26
Invasive Species	250	0	C-26
New and Emerging Invasive Species	**2,000**	**4**	C-26
Invasive Species	2,000	4	C-26
Pollinators	**1,560**	**6**	C-27
Status and Trends	1,210	6	C-27
Science Synthesis, Analysis and Research Program	350	0	C-27
Coastal Resilience and Landscapes	**5,109**	**13**	C-28
Climate Outputs	**500**	**2**	C-29
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	500	2	C-29
Coastal Land Use Change and Sea Level Rise	**200**	**1**	C-30
Land Change Science	200	1	C-30
Contaminant Network Along the Northeast Coast	**1,300**	**3**	C-30
Toxic Substance Hydrology	1,300	3	C-30
Imagery Datasets and Analytical Tools for Coastal Analysis	**500**	**2**	C-31
Land Remote Sensing	500	2	C-31
Coastal Resilience and Vulnerability	**2,109**	**3**	C-31
Coastal & Marine Geology	2,109	3	C-31
Sea Level Rise Models	**500**	**2**	C-32
National Cooperative Geologic Mapping Program	500	2	C-32
Grand Total	**15,569**	**47**	

Justification of 2016 Program Changes (+$15,569,000/+47 FTE)

Critical Landscapes (+$6,650,000/+24 FTE)
Invasive and Declining Species (+$3,810,000/+10 FTE)
Coastal Resilience and Landscapes (+$5,109,000/+13 FTE)

Overview

Interior, along with many other Federal and State agencies, local communities, tribes and regional coalitions manage their resources at the landscape scale, which requires understanding of many complex relationships between environmental and manmade factors. Land uses are increasingly interconnected and competitive. To inform decisions on siting energy development, allocating water resources, recreational opportunities, conservation of habitat, mitigation of development activities, and other land uses requires an understanding of the components within the landscape and how to balance a variety of uses and maintain a sustainable and resilient ecosystem. In 2016, the USGS is requesting an increase of $15.6 million to expand, enhance, and initiate science activities is several areas to increase the understanding of the Nation's landscapes and how they work. One component expands science efforts at specific locations—the Arctic, Columbia River, Puget Sound, Upper Mississippi River, Great Lakes, and sage steppe habitat. Adding to these efforts are science activities of invasive species and species in decline. Another component builds on Hurricane Sandy efforts and initiates new work in coastal resilience and emerging contaminants and chemical mixtures.

Critical Landscapes (+$6,650,000/+24 FTE)

The Changing Arctic	(+$4,200,000/+16 FTE)
Columbia River (Salmon)	(+$600,000/+1 FTE)
Puget Sound	(+$750,000/+1 FTE)
Science for the Sage steppe Landscape	(+$1,000,000/+5 FTE)
Upper Mississippi River	(+$100,000/+1 FTE)

Overview

Knowledge of ecosystems is critical to the well-being of the Nation because ecosystems supply the natural resources and other goods and services that humans require. The scope of science needed to improve conservation and restoration of ecosystems is complex. In many ecosystems, regional environmental resource issues challenge decisionmakers and place them at a critical juncture to balance human needs with ecosystem health. The multidisciplinary approach applied by the USGS is necessary to develop an understanding of both individual ecosystem processes and holistic ecosystem level evaluations of responses to actual and proposed restoration alternatives and plans. Science enables resource managers to make informed decisions, to help resolve and prevent resource management conflicts, and to support Interior's public trust stewardship responsibilities for the Nation's lands and waters. Increases in 2016, support research and development efforts focused in the Arctic, Columbia River, Puget Sound, Upper Mississippi River, and Sage Steppe Landscape. In addition to these increases, USGS research will continue to support other priority ecosystems such as Chesapeake Bay, Everglades, Great Lakes, California Bay Delta, and the Gulf Coast. These multi-disciplinary projects are designed to serve local ecosystem management needs and provide knowledge and approaches transferable to similar ecosystems across the Nation.

Program Performance

The Changing Arctic **(+$4,200,000/+16 FTE)**

Environments Program	(+$700,000/+5 FTE)
National Climate Change and Wildlife Science Center/ DOI Climate Science Centers (CSCs)	(+500,000/+4 FTE)
Land Remote Sensing	(+$250,000/+1 FTE)
Coastal and Marine Geology Program	(+$2,000,000/+4 FTE)
Water Availability and Use Science	(+$750,000/+2 FTE)

The USGS can contribute significantly to supporting communities and resource managers in understanding changes in the Arctic that impact ways of life and the long-term resilience of ecosystems and communities. The Arctic is warming faster than any other region on Earth. In areas such as Alaska, observations show that the vast majority of glaciers are losing mass at an astounding rate, while rapid permafrost loss can be seen from coastal areas to inland forests and tundra. In turn, shrinking permafrost and glaciers have brought a host of impacts to the broader physical environment, such as the formation of thermokarst lakes (land-surface configuration that results from the melting of ground ice in a region that creates the lake, sinkhole, tunnel, etc.), altered streamflow paths and regimes, disruption of ocean currents, and sea-level rise. Less well understood is how glacier and permafrost change alters downstream ecosystems and the resources they provide. The USGS will take a whole-system approach to study the many dimensions—physical, biological, social and economic—of permafrost and glacier loss. This approach will be driven by the near-term needs of stakeholders, and will build cross-disciplinary teams of scientists using a blend of measurements, conceptual modeling, and process modeling within a collaborative framework as a means to clarify the linkages between climate, glaciers and human impacts. This effort will build on a rich legacy of Federal science in the Arctic, while also capitalizing on capacity from the broader research community. Completion of this project will allow managers in the Arctic to understand the potential climate impacts to glaciers and determine potential changes in production of salmon and migratory waterfowl, wildfire regimes across Alaska and changes in permafrost.

Environments Program (+$700,000/+5 FTE)

While the Arctic region has experienced warming and cooling cycles over millennia, the current warming trend is unlike anything previously recorded and is affecting the region faster than any other place on Earth, bringing dramatic reductions in sea ice extent, altered weather, and thawing permafrost. Implications of these changes include rapid coastal erosion threatening villages and critical infrastructure, changes to wildlife habitat, increased greenhouse-gas emissions from thawing permafrost, threats from invasive species, and potentially significant impacts on subsistence activities and cultural resources. Changing habitats and related impacts to species are of great importance to land and wildlife managers as well as indigenous peoples. Federal, State, and tribal managers need to understand how climate, in particular, is impacting the lands and species for which they are responsible, and what actions may be warranted to protect those resources for. As development continues to be proposed for many parts of Alaska, but especially the Arctic Slope, managers must understand the trajectories of change and attempt to forecast additional impacts from development both to honor commitments to Native Americans and to

help conserve these natural resources. The USGS is committed to applying assessment and analysis techniques to the species and habitats of Alaska, especially the North Slope, to help provide the information, models, and other tools that managers need to support difficult decisionmaking.

Climate changes have the potential to affect the outcomes of various resource management decisions such as those in energy development, wildlife disease management, and Native American subsistence harvests. The Environments program would use the requested funding to work with scientists from other parts of the USGS and partner agencies to analyze potential changes to distributions and condition of fish and wildlife populations and their habitats as a result of climate changes and human activities. Although it is fairly certain that climate-induced changes to animal populations and habitats will occur, predictions about the precise nature of those changes remain uncertain. Management strategies designed to offset these changes are hampered by uncertainty in how climate change will affect both species' occurrence (i.e., distribution) and within-season timing (e.g., growth, reproduction, migration). The program will seek to develop quantified methods to assess plant and animal responses simultaneously at species and community levels to explicitly incorporate shifts in species' responses to climate variables. Qualitative and quantitative methods would be useful for developing and testing monitoring approaches for fish and wildlife species of importance to Alaska. Such methods have application beyond taxa in Alaska and could be applied across systems where there is a desire to predict the species changes and shifts in life history timing in response to climate change or development.

National Climate Change and Wildlife Science Center/
DOI Climate Science Centers (CSCs) (+500,000/+4 FTE)

The National Climate Change and Wildlife Science Center/Climate Science Center (NCCWSC/CSC) Program would use the requested funding increase to develop a process to estimate total glacier loss in Alaska and potential changes in freshwater input. These estimates would be used along with projections of future changes in climate, fire regimes, vegetation, and water flows, produced by the program's recently completed Alaska Integrated Ecosystem Model (AIEM). The AIEM is an ecosystem model for Alaska and Northwest Canada. This modeling tool is capable of forecasting how landscape structure and function might change in response to climate changes. This tool is capable of providing scenarios of changes in landscape structure and function that could be used by resource-specific impact models to assess the effects of climate change on natural resources. The information from the requested increase will be used by managers of high priority species such as goose and caribou to identify potential impacts and identify management options.

Land Remote Sensing (+$250,000/+1 FTE)

The Land Remote Sensing (LRS) program would use the requested increase to contribute to the development of predictive models, which support the evaluation of changes to the environment resulting from the conversion of permanently sequestered ice and snow to liquid and gaseous water. Multi-temporal and multi-resolution remote sensing data from satellites and airborne systems (Landsat, Classified Systems, Aircraft, and Unmanned Aerial Systems) would be used in combination with field level studies and in-situ observations to measure changes of ice and snow volumes and support the

development of predictive models of the impacts from climate-induced changes. This work would build on initial research being conducted in the development of an Essential Climate Variable for permafrost.

Coastal and Marine Geology Program (+$2,000,000/+4 FTE)

The proposed increase will enhance the capacity of the Coastal and Marine Geology Program (CMPG) to work with communities, the Bureau of Indian Affairs, and the Office of Insular Affairs (OIA), to deliver assessments of coastal vulnerability to storms, erosion, and sea-level rise for communities along the Alaskan Arctic and Bering Sea coasts and throughout U.S. Island Territories and Freely Associated States. The livelihoods of these remote communities are linked to their coastal landscapes, resources and infrastructure, and are threatened by impacts from storm-related flooding, permanent inundation and coastal change associated with climate change. Tools to assess vulnerability and anticipate future change, and to develop sustainable strategies to respond and adapt to change while preserving cultural, economic and environmental health are needed. Application of CMGP tools developed for the ocean coasts of the lower 48 States requires development of foundational data and enhancements to reflect the unique character and processes of these vulnerable landscapes. Through this effort, the CMGP will assess and address critical data and knowledge gaps and, for priority communities, begin to synthesize the data and knowledge into tools that will support development of effective and sustainable strategies to respond to changing conditions. Initial pilot assessment and forecast products will provide a widely accessible framework and strategy for a sustained and longer-term effort to address the requirements of the widespread communities throughout these regions. Resulting data and products will be delivered through the USGS Coastal Change Hazards Portal, which enables access through Federal ocean and climate data and toolkit services that facilitates broad access and application.

Consultation with tribes, State, and other entities Alaska and the Arctic, and with Interior resource managers, would guide systematic prioritization development of products for this region where vulnerable landscapes, ecosystems, and communities face impacts of coastal change in response to sea-level rise, changing ice-cover, storms, and increasing shoreline retreat associated with permafrost decline, inundation, and land subsidence. Substantial data gaps, including mapping of coastal landscapes and change, would be addressed to provide observational inputs to coastal vulnerability and change forecasts. Field programs would focus on development of coastal change assessments and forecasts reflecting processes and conditions unique to this region and of particular concern to native communities and Interior resource managers. Initial development in selected priority communities would establish the framework and requirements for broader development and provision of data, forecasts and decision-support tools. The CMGP will work with other Federal agencies (Interior: BIA, NPS, BLM, FWS, BOEM, USACE, NOAA), regional Climate Science Centers and LCCs, State agencies, and interagency Arctic/Alaska councils to define priorities and leverage efforts as is required to develop substantive products in these remote, unique, and operationally challenging regions.

Coastal communities throughout the Island Territories (including the Freely Associated States) are dependent on coral reef systems to buffer storm and coastal flooding impacts, to sustain fisheries and biodiversity, and for other economic and cultural benefits. Coral reefs are particularly vulnerable to sea-level rise, changing storm climate, ocean warming, and ocean acidification. The USGS will conduct research to enhance our understanding of the response of coral reef-associated shorelines to climate

change and other stresses. Research results will include updated data and development, and validation of physical models that predict vulnerability of coral reef seascapes and adjacent landscapes to climate change, sea-level rise, and storm impacts. The resulting data and models will assist resource managers and coastal communities in assessing the sustainability of infrastructure, food and agricultural, and groundwater resources. Assessment and forecast products will be developed to meet the requirements of island communities to design and evaluate sustainable and effective strategies to enhance coastal resilience and adapt to coastal change.

Water Availability and Use Science Program (+$750,000/+2 FTE)

Permafrost has accelerated altering surface water and groundwater distribution, flow and quality; ice-jam flooding; land surface features; lake and wetland dynamics; health of aquatic and terrestrial ecosystems, ocean currents; and sea level. Permafrost thaw and the naturally accompanied changes in water flow and distribution is having important economic consequences on roads and other infrastructure. The Water Availability and Use Science Program would use the requested increase to address the most urgent scientific and social questions stemming from warming in the Arctic with input from Federal, State and tribal resource managers and collaborative efforts among cross-interdisciplinary teams of scientists. Among the issues to be addressed would be the effect of permafrost thaw on surface water and groundwater and carbon and mercury export to surface waters.

Columbia River (Salmon) **(+$600,000/+1 FTE)**

Environments Program (+$150,000/0 FTE)
Contaminant Biology (+$50,000/0 FTE)
Toxic Substances Hydrology (+$50,000/+1 FTE)
National Geospatial Program (+$350,000/0 FTE)

The Columbia River is the largest river in the Pacific Northwest, and plays an important role in the region's culture and economy through tribal fisheries, irrigation, power production, and recreation, among other goods and services. This system has been affected by a number of anthropogenic changes, including altered flows, environmental contaminants, and invasive species that have degraded the ecosystem. Managers and policymakers require scientific information to prevent the decline of critical species such as salmon, which are a valued tribal trust species; to manage ecological flows in this engineered river system; and to reduce risks from habitat degradation, changes in species composition, and climate change. With the proposed increase, the USGS would enhance documentation of the life history, habitat requirement, and population status and trends of forage fish, critical as a food source to other species, supporting fish, bird and mammals. The USGS would address invasive species, related climate impacts, chemical and physical habitat degradation, and effects on economic and trust species. USGS scientists would conduct research on the effect of altered flow regimes due to climate change and dam operations on habitats. A new Columbia River Treaty with Canada, which would take effect in 2025, could potentially affect flow regimes. USGS researchers would characterize ecological tradeoffs related to alternative flow regimes, as they affect physical habitat features, food webs, and ecological interactions influencing the sustainability of salmon, sturgeon, and other key species populations. The research results would help decision makers address flow regimes as required by the treaty. The USGS would combine

data acquisition efforts with the Science Application for Risk Reduction (SAFRR) project to better leverage multiple science uses for high-resolution lidar data, through 3DEP, over ecosystem and natural hazard projects in the Columbia River area. The SAFRR develops natural hazard disaster scenarios as a strategy to increase community resilience or a community's ability to cope with the effects of a disaster. This work builds upon what was started in 2015.

USGS researchers would continue to investigate the effects of endocrine-disrupting chemicals (EDCs) on fish and wildlife in the Columbia River through laboratory and field investigations in four critical areas: (1) investigations into adult onset immune suppression following early life stage exposure of EDCs; (2) development and application of fish models to better understand EDC-induced immune suppression and disease resistance; (3) characterization of fish and wildlife models for trans-generational effects of EDCs; and (4) studies to identify reproductive effects of chronic low-dose exposure in several species including endangered sturgeon.

In addition, research into contamination of the Columbia River and its wetlands with metals, including mercury, would investigate the potential biological effects of these metals on aquatic insects, including the potential to influence maturation of aquatic larva to terrestrial adults, contaminant bioaccumulation, and the movement of these metals through the food chain.

Puget Sound **(+$750,000/+1 FTE)**

Environments Program	(+$200,000/0 FTE)
National Water Quality Program	(+$100,000/+1 FTE)
National Geospatial Program	(+$450,000/0 FTE)

Puget Sound, the second largest estuary in the United States, provides diverse benefits to a growing regional human population. It provides a home, recreation, and economic opportunity to millions of people. The Sound is a natural resource treasure, supporting hundreds of species of fish, sea birds, and marine mammals, many of which are of enormous economic and cultural importance to the region. Human development and land use changes will likely affect the future sustainability of the Sound, particularly watershed and shoreline alterations that are likely to reduce critical habitat for species and reduce water quality. More than 20 Native American tribes are protected in perpetuity in their uses of salmon. However, salmon are in decline due to reductions in habitat quantity and quality. The USGS is providing critical science to support priorities of a major ecosystem restoration effort involving tribal, local, State, and Federal entities. The proposed increase in 2016 would support managers and decision makers by developing process-based monitoring and models at the ecosystem scale to identify and address risks to salmon. These models, based on current and historic monitoring, help decisionmakers identify the key species and processes in the ecosystem for appropriate protections, controls, and monitoring. In addition, the USGS would investigate the status of forage fish populations—some of which are in decline—and identify linkages between population dynamics, bioenergetics, predation, habitat alterations, disease, and food availability. In support of the restoration, this work would result in new molecular tools and sampling methods. The USGS would combine data acquisition efforts with the SAFRR project to better leverage multiple science uses for high-resolution lidar data, through 3DEP over ecosystem and natural hazard project in the Puget Sound area. Finally, the recent removal of two major

dams on the Elwha River is one of the largest river restoration projects in history, requiring active management of former submerged reservoir lands; use of hatcheries to supplement wild fish populations; and monitoring of specific aquatic, terrestrial, and near-shore marine responses of the ecosystem. This work builds upon what was begun in 2015. USGS science would provide managers with information on ecosystem responses to specific post-removal restoration actions to ensure that restoration is effective.

The remarkably diverse and resilient habitats of the Puget Sound estuary provide a wide range of ecosystem benefits, including significant current and potential carbon sequestration across the seagrass - marsh - tidal forest transect. The National Water Quality Program is proposing a funding increase to build upon an investment started in 2015 that focuses on carbon cycle modeling in the Nisqually National Wildlife Refuge, and other neighboring field sites (Snohomish Estuary to the north). These areas in the Puget Sound need greater accounting of carbon stocks and fluxes in order to comply with statutory and regulatory requirements. Carbon accounting is needed in a changing world in order to support management decisions that can maximize estuarine resilience and ecosystem services, from carbon sequestration to wildlife support.

Science for the Sage Steppe Landscape **(+$1,000,000/+5 FTE)**

Environments Program (+$1,000,000/+5 FTE)

The North American sage steppe landscape covers about 120 million acres, extending across 11 Western States and parts of 2 Canadian provinces. Sixty percent of the sage steppe landscape is in public ownership, with the Interior managing 51 percent of these lands. Sage steppe provides the primary habitat for greater sage-grouse, a species that the FWS is considering for Federal listing in a determination due in September 2015. The sage steppe landscape has been significantly altered by multiple stressors, including increasing incidence of large wildfires, rapid spread of invasive cheatgrass that alters natural fire regimes, expanding energy development, and other human land uses. These changes have resulted in significant loss, fragmentation, and conversion of landscapes once dominated by sage steppe, and they have had a resulting negative effect on greater sage-grouse, a species that now occupies less than half of its historic range. The USGS is conducting research to understand the changes in the sage steppe landscape, and how these changes impact species, like greater sage-grouse, which depend on this habitat for survival. A significant portion of this research is focused on understanding changes at a large, multi-jurisdictional landscape scale, developing the tools and techniques that State and Federal managers need to respond to these changes. With this initiative, the USGS would expand its fire and restoration research to better understand the effects of repeated fires on the sage brush ecosystem and the efficacy of restoration activities by Interior partner agencies. Research projects include development of models to predict the effect of a changing fire regime and habitat fragmentation on the persistence of sage grouse populations, understanding the significance of climate change in the sage steppe landscape, and developing and testing alternative sage steppe restoration/rehabilitation strategies.

This information will help inform restoration, rehabilitation, and mitigation practices for greater sage-grouse habitat within the context of ecosystem management to increase resilience. These evaluations will span the entire range of the greater sage-grouse, and will provide decision-makers the information to make landscape-scale decisions. This unprecedented, landscape-level study will provide critical

information on (1) implementation strategies (equipment, methods, seed sources and transfer guidelines, site prioritization) that maximize habitat restoration for greater sage-grouse, and (2) rates and likelihood of sage steppe establishment given to losses from fire and other activities. This information is relevant to State and Federal agencies, including but not limited to State land, fish and wildlife agencies, the USFS, BLM, NPS, and FWS.

This initiative provides a direct link to the Secretary's priority on Landscape Level Understanding by focusing on a high priority landscape and providing the science needed for managers to make landscape-scale decisions. All the research will be planned and implemented in close collaboration with Interior Bureaus (BLM, NPS, and FWS).

Upper Mississippi River **(+$100,000/+1 FTE)**

National Water Quality Program (+$100,000/+1 FTE)

The National Water Quality Program would build upon a 2015 investment into Upper Mississippi River Basin (Basin) with a requested increase in 2016 to perform more data collection and interpretative studies on water quality in the Upper Mississippi Region. The Basin contains a wide diversity of landscape types that include major agricultural operations and headwaters with major urban landscapes. Both landscape types can have negative impacts on aquatic ecosystem health of the Mississippi River and connecting rivers downstream resulting in maintaining or expanding hypoxia conditions in the Gulf of Mexico. Existing USGS programs in this region are developing a better understanding of water resources through critical streamflow measurement stations that characterize water quality. The proposed increase would be used to support additional monitoring of nutrients and sediment used to develop water quality models that would help States and local agencies prioritize their efforts towards the largest sources of nutrients in the Basin. Data and interpretive studies addressing water quality concerns are shared with State and local partners in this five State region (Minnesota, Wisconsin, Illinois, Iowa and Missouri).

Invasive and Declining Species (+$3,810,000/+10 FTE)

Brown Tree Snakes – Detection and Control (+$250,000/0 FTE)
New and Emerging Invasive Species (+$2,000,000/+4 FTE)
Pollinators (+$1,560,000/+6 FTE)

Overview

Nonindigenous invasive plants and animals cause significant economic losses and diminishing opportunities for beneficial uses of forests, croplands, rangelands, and aquatic resources. Costly effects include clogging of water facilities and waterways, wildlife and human disease transmission, threats to commercial, native, and farmed fisheries and increased fire vulnerability and adverse effects for ranchers and farmers. Across the Nation, the USGS partners with States, tribes, other Federal agencies, businesses, agriculture, natural resource managers, and the private sector to help solve problems posed by all significant groups of invasive organisms in terrestrial and aquatic ecosystems. Increases in 2016

would continue research and development efforts focused on the brown tree snakes in Guam and new and emerging invasive species of national concern.

Insects, birds, and mammals, that are pollinators, are critical to agriculture and the economy. The USGS and other scientists are documenting alarming declines in pollinators. In 2016, the USGS, in collaboration with the U.S. Department of Agriculture, will study land use, land condition, and land cover as they relate to pollinator habitat needs, including restoration efforts; study the use of pesticides; and provide data and tools to the American people to promote healthy habitats across the country.

Program Performance

Brown Tree Snakes – Detection and Control

Invasive Species (+$250,000/0 FTE)

Shortly after World War II, the brown tree snake (BTS) was accidentally transported from its native range in the South Pacific to Guam. Because of abundant prey on Guam and the absence of natural predators and other population controls, BTS populations reached extraordinarily high numbers. Snakes have caused the extinction of most of the native forest vertebrate species; thousands of power outages affecting private, commercial, and military activities; and widespread loss of domestic birds and pets. The highest priority needs for control and management of BTS are the development of landscape-scale methods to suppress or eradicate snakes on Guam, and to detect and eradicate incipient populations of snakes accidentally transported to other islands such as Hawaii and the Northern Mariana Islands. The military expansion on Guam will raise the profile of these issues because military construction will result in mitigation actions that include snake suppression in areas of high ecological value, and because increased military cargo transport and off-Guam training exercises will increase the odds of transporting snakes to other islands, such as Hawaii. With the increased funding, the USGS would build on continuing work focusing on high-priority research to validate the efficacy of aerially-delivered toxicants for snake control at landscape-scales; predicting the results of snake suppression on Guam and the increase of potentially problematic species (such as non-native rats); increasing the number of trained snake rapid responders in Hawaii and other islands at risk of receiving BTS transported from Guam; and conducting a thorough assessment of the possibility that scattered reports of snakes sighted in the U.S. Commonwealth of the Northern Mariana Islands represent an established population.

New and Emerging Invasive Species (+$2,000,000/+4 FTE)

Invasive Species (+$2,000,000/+4 FTE)

The introduction, establishment, and spread of invasive species will be important drivers of biodiversity loss over the next century and will pose substantial risks to native species, valued ecosystem services, and human and wildlife health. Ongoing global changes such as more-frequent transcontinental and transoceanic trade and tourism, land and water use changes, and climate change are facilitating ever-faster rates of establishment and spread of harmful, invasive plant and animal species around the world. Challenges for scientists will be to determine which newly established nonnative species might cause

significant impacts and become high priority invaders, and accurately estimate their potential spread throughout the country. While many invaders cause little or no observed change in the invaded ecosystem, a small percentage of species that become established alter ecosystem structure and function in detectible and deleterious ways. USGS research on current high priority invasive species such as tamarisk in the Southwest, nutria in the Gulf of Mexico, Burmese pythons in the Everglades, and Asian carp in the Mississippi River Basin provides information to identify the next generation of invaders and to forecast their impacts. Assessing the factors influencing known invasions improves the national ability to predict invasions and to take preventative measures early enough to better address new invasive species.

This increase would allow the USGS to enhance ongoing efforts focused on the development, evaluation, and improvement of tools for early detection and control of existing and emerging invasive species. The USGS would develop and improve the power of advanced molecular detection tools (such as eDNA and fecal source tracking) to detect invasive species at very low densities in the field, such as sea lamprey. These USGS research endeavors would provide information for assessments of risk and predictions; determine effects of invasive species; develop tools and innovative methods for control and management; and deliver information management tools to more effectively integrate and use available data on invasive species. In addition, the USGS Nonindigenous Aquatic Species database (*http://nas.er.usgs*) would be expanded to provide information and data on aquatic invasive plants, information needed by our Interior and other partners to manage new and emerging plant invaders. The end result would be a collection of early detection tools for invasive species to enhance capability for early detection and control of currently established and emerging invasive species and to ensure that the Nation is better prepared for the next—yet unknown—generation of invasive species. This research would address invasive species and ecosystems of concern for our Interior partner agencies and would be coordinated with the National Invasive Species Council.

Pollinators **(+$1,560,000/+6 FTE)**

Status and Trends	(+1,210,000/+6 FTE)
Science Synthesis, Analysis and Research	(+$350,000/0 FTE)

The Pollinators Initiative will address research priorities identified through the 2014 Presidential Memorandum on Pollinator Health, through the development of studies, monitoring programs, and decision tools for land and resource management agencies, such as the National Protocol Framework for the Inventory and Monitoring of Bees, and pollinator habitat models. The USGS would expand the small group of researchers who work directly on pollinators. The USGS would support scientists who work on habitat characteristics, ecosystem services, disease and pesticides toward pollinator issues.

USGS scientists work closely with the U.S. Department of Agriculture (USDA), which is interested in ensuring that honeybees have adequate forage throughout their lifespan. The initiative would support increased interaction between the USGS and Interior bureaus to support management of lands to support pollinators, and ensuring that populations of native species are maintained. Partnerships would also be expanded, including the Pollinator Partnership, a consortium comprised of local, regional, tribal and national governments, corporations, universities and others that work to protect the health of managed and native pollinating animals vital to our North American ecosystems and agriculture, and the Monarch Joint

Venture, a partnership of Federal and State agencies, non-governmental organizations (NGO), and academic programs that are working together to support and coordinate on-the-ground conservation efforts to protect the monarch migration across the lower 48 United States.

The proposed increase would allow the USGS to significantly augment its interdisciplinary pollinator science program to:

- Expand existing collaborations with the USDA to study the patterns, processes, and consequences of changes in land use, land condition, and land cover as they relate to pollinator habitat needs including forage, nesting, and other requirements.
- Work with land management agencies to translate habitat needs into effective restoration strategies and monitor effectiveness of restoration activities.
- Expand science in support of FWS efforts to conserve and restore healthy monarch butterfly populations.
- Conduct research on the cumulative impacts of pesticides.
- Collaborate with the FWS to refine and test the National Protocol Framework for the Inventory and Monitoring of Bees.
- Build capacity for identification and taxonomy of native bees, in partnership with USDA and non-federal partners.
- Provide information and tools in support of other Federal agencies' outreach and education activities to promote healthy habitats across the country.
- Create maps and analyses for habitats of critical concern for pollinators with areas of greatest potential for mitigation and restoration activities.
- Enhance existing online repositories of pollinator occurrence data to capture national distributions, ranges and potential ranges for important pollinator species including predicted ranges in light of climate change.

Coastal Resilience and Landscapes (+$5,109,000/+13 FTE)

Climate Outputs	(+$500,000/+2 FTE)
Coastal Land Use Change and Sea Level Rise	(+$200,000/+1 FTE)
Contaminant Network Along the Northeast Coast	(+$1,300,000/+3 FTE)
Imagery Datasets and Analytical Tools for Coastal Analysis	(+$500,000/+2 FTE)
Coastal Resilience and Vulnerability	(+$2,109,000/+3 FTE)
Sea Level Rise Models	(+$500,000/+2 FTE)

Overview

U.S. populations, critical infrastructure, and economies, are concentrated in coastal regions and are at substantial risk from coastal hazards and long-term change. Major storms impact lives and livelihoods

with economic costs in the billions, and unquantified but equally consequential social and environmental costs. The security, vulnerability, and resilience of the physical, ecological, and human components of coastal systems are intimately linked. Enhancing resilience and reducing vulnerability as change accelerates due to increasing development and the consequences of climate change requires data, knowledge, and tools to assess coastal vulnerability; to develop effective and sustainable strategies to enhance resilience; and to forecast the impacts of future conditions and processes on environmental and economic health and public safety. This initiative engages numerous USGS programs to develop and integrate their proven capabilities to provide the foundational data, methods, and knowledge to enhance our ability to assess and forecast coastal vulnerability and the efficacy of strategies to increase resilience and adapt to change.

The activities will improve understanding of the vulnerability of coastal resources and communities and will inform strategies to enhance coastal resilience and adapt to coastal change. In meeting immediate needs, they will also establish and demonstrate the effectiveness of a more comprehensive effort to provide and apply the breadth of USGS science capabilities to the diverse and widespread coastal settings of the Nation. As a result of this effort the USGS will provide data, understanding and tools that advance our understanding of coastal vulnerability to storms and sea-level rise including: (1) data, tools, and forecasts that will enable coastal resource managers to anticipate future consequences of coastal change and to assess the efficacy and sustainability of alternative management strategies, including "green" or "nature-based" approaches; (2) information to assess the potential for storm-driven dispersal of contaminants and the short-term and persistent consequences of resulting human and environmental exposure to support effective mitigation and response; (3) geospatial characterization of the landsurface and landcover, including post-event mapping of change, required to assess ecological and human vulnerability and for modeling of impacts and change; (4) enhanced records of past sea-level and storm impacts to improve models and understanding of the potential scale and extent of future change; and (5) methods to characterize and communicate risk and vulnerability so that communities can design strategies based on consistent, comparable, and meaningful estimates of costs and benefits.

Program Performance

Climate Outputs **(+$500,000/+2 FTE)**

National Climate Change and Wildlife Science Center/
DOI Climate Science Centers (CSCs) (+$500,000/+2 FTE)

The National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs) Program, working closely with the Coastal and Marine Geology Program (CMGP), would use the requested increase to bring structured decision making approaches that integrate the latest sea-level rise projections to refuge and other land managers in the Southeastern United States, the Hawaiian Islands, and the west coast. Specifically, the program would identify management endpoints for land managers in coastal zones and develop approaches that link climate outputs with models to inform the decisionmaking process. The land managers would then use this information in decisionmaking in areas such as restoration of habitat or protection or conservation of species.

Coastal Land Use Change and Sea Level Rise **(+$200,000/+1 FTE)**

Land Change Science (+$200,000/+1 FTE)

The requested increase would develop tools for estimating the risks and potential benefits and costs of various sea-level rise and storm surge mitigation measures. Program researchers would assess the impacts and risks stemming from coastal land use change on communities and their potential vulnerability. In order to mitigate, prepare for, and recover from disasters, public officials and at-risk communities need a clear understanding of societal risk to create strategies for increasing resilience to both to sea-level rise and storm surges.

Contaminant Network Along the Northeast Coast **(+$1,300,000/+3 FTE)**

Toxic Substances Hydrology (+$1,300,000/+3 FTE)

Enhanced dispersal and concentration of contaminants (including chemicals and pathogens) from a wide array of municipal (wastewater), industrial (chemical storage and processing facilities), and residential sources in coastal regions due to storm-induced disturbances could decrease the health and resilience of coastal communities and ecosystems in coming years throughout the United States. As part of the Hurricane Sandy supplemental, the USGS received $2.0 million in 2014, and is establishing a contaminant vulnerability assessment network based on a prioritized monitoring and modeling infrastructure supported with extensive landscape-scale assessments of potential contaminant sources. The requested increase would augment that ongoing effort by: (1) enabling the establishment of real-time water quality monitoring capabilities in key locations associated with the network along the northeast coast, and (2) supporting the development of standard operating procedures to prioritize areas vulnerable to contaminant impacts based on the real-time monitoring network and other factors, as well as (3) the rapid deployment and mobilization of field crews for environmental sample collection (including water, soils, and sediment). This will be developed in close collaboration with local, State, tribal, and other Federal partners, including public health agencies commonly engaged in first response actions.

Network monitoring sites will be collocated where possible in partnership with a separate USGS effort led by the Water Mission Area, and funded by the Hurricane Sandy supplemental, which is establishing a Surge, Wave, and Tide Hydrodynamics (SWaTH) network along the northeast coast. The requested increase will enable real-time water quality sensors to be sited on a subset of SWaTH sites. Interpretation of these data in context with the associated landscape-scale assessments of contaminant sources and modeling will provide supporting information required to mitigate those sources in the short term and minimize their impact for future events. Lessons learned from the establishment of this network can be applied to other coastal areas of the United States. The data would be used to mitigate contaminant threats and could also be used to help design more extensive networks of a similar nature.

Imagery Datasets and Analytical Tools for Coastal Analysis **(+$500,000/+2 FTE)**

Land Remote Sensing (+$500,000/+2 FTE)

The Land Remote Sensing (LRS) Program would use the requested funding increase to work with the Land Change Science (LCS) Program and other USGS and interagency partners to develop new datasets to support dynamic coastal land change analysis for improved coastal resource management and resilience planning. The LRS program would support more frequent National Land Cover Database (NLCD) based sources of land change information including interim and ongoing monitoring especially after significant storm events. The LRS program would primarily develop datasets that exploit new elevation technologies (to augment 3DEP), hyperspectral capabilities, and various platforms to include Unmanned Aerial Systems. The LRS program would provide analytical tools for integrating repeat elevation and spectral data to characterize the impacts of coastal change and severe weather events on terrestrial and aquatic vegetation health, and other features that play a role in coastal resilience and flood inundation. Prototype datasets would be developed for one or two priority areas and made available for peer-review evaluation and for use in sea-level rise modeling exercises that will occur within the CMGP and NCCWSC/CSC program.

Coastal Resilience and Vulnerability **(+$2,109,000/+3 FTE)**

Coastal and Marine Geology Program (+$2,109,000/+3 FTE)

This requested increase will enable the Coastal and Marine Geology Program **(**CMGP) to build upon datasets, regional geologic studies, and models of coastal change and vulnerability developed and enhanced with supplemental funding in the aftermath of Hurricane Sandy. Activities will focus on Interior and other Federal lands and managed resources in the mid-Atlantic region and, in collaboration with established USFWS, NPS, and other Federal partners, lead to improved assessments and forecasts of the vulnerability of coastal lands and resources to future extreme storms and sea-level rise. Data, tools and models will be developed to assess the effectiveness and sustainability of existing and alternative strategies for enhancement of natural system resilience and the associated benefits in terms of reduced vulnerability of coastal infrastructure and communities. Field studies will address specific resources at management-relevant scales to assess coastal vulnerability and resilience to extreme events and persistent change across the entirety of barrier-island, bay/estuary, and wetland systems. Data, tools, and forecasts will enable coastal resource managers to anticipate future consequences of coastal change and to assess the efficacy and sustainability of alternative management strategies, including “green” or “nature-based” approaches. Updated assessments will be provided after extreme events, and as changes occur due to persistent change or management actions. Tools will be provided to enhance resource resilience, reduce vulnerability of adjacent infrastructure and communities to future storms and sea-level rise, and to assess the success of management actions and the science on which they were based. Resulting data and products will be delivered through the USGS Coastal Change Hazards Portal which enables access through Federal ocean and climate data and toolkit services that facilitate broad access and application.

Sea Level Rise Models **(+$500,000/+2 FTE)**

National Cooperative Geologic Mapping Program (+$500,000/+2 FTE)

The National Cooperative Geologic Mapping Program (NCGMP) would use the increase to build upon regional geologic studies to better understand climate extremes in the geologic record; to understand the footprint that large storms leave on the landscape (both onshore and offshore) in California; and to better understand climate signals in the Coastal Plain formations of the Atlantic Coastal Plain (e.g., Paleocene-Eocene Thermal Maximum). These paleoclimate indicators are generally discovered through careful examination of sediment core samples involving sediment description, geochronology, paleontology, and geochemistry. The information gathered would enable coastal resource managers to design resiliency strategies for future storms, and longer-range trends such as sea-level rise.

Natural Hazards Science

Natural Hazards Science ($ in Thousands)	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Natural Hazards Science for Disaster Response	**6,618**	**10**	C-34
Expanding Use of Flood Inundation Mapping and Rapid Deployable Streamgages	**700**	**4**	C-34
Groundwater and Streamflow Information Program	700	4	C-34
Rapid Response to Volcano Unrest and Eruption, and Associated Hazards	**0**	**0**	C-35
Volcano Hazards	0	0	C-35
Earthquake Early Warning and Rapid Event Characterization	**-1,502**	**-2**	C-36
Earthquake Hazards	-1,502	-2	C-36
GSN Primary Sensor Deployment	**4,920**	**2**	C-37
Global Seismographic Network	4,920	2	C-37
Improved Geomagnetic Monitoring to Support Space Weather Nowcasting	**1,700**	**3**	C-37
Geomagnetism	1,700	3	C-37
Landslide Response	**500**	**2**	C-38
Landslide Hazards	500	2	C-38
Rapid Wildfire Science Response	**500**	**2**	C-39
Environments Program	500	2	C-39
Building Sinkhole Hazard Response Capability	**200**	**0**	C-40
National Cooperative Geologic Mapping Program	200	0	C-40
Disaster Scenarios and Strategic Science Crisis Response	**300**	**1**	C-40
Land Change Science	300	1	C-40
Precision Monitoring for Non-Seismic Fault Activity	**-700**	**-2**	C-41
Earthquake Hazards	-700	-2	C-41
Grand Total	**6,618**	**10**	

Justification of 2016 Program Changes (+$6,618,000/+10 FTE)

Overview

Every year the United States faces disasters that threaten the Nation through loss of life and property, degradation of human health and the environment, and impacts to national security and economic vitality. In domestic and global events, the Nation's emergency managers and public officials look to USGS science to inform them of the risks hazards pose to human and natural systems and how to reduce losses and improve response. Major events in the last several years include the Napa, California earthquake; landslides in Washington State and Colorado; Midwest flooding; Hurricane Sandy; Japan's Great Tohoku earthquake and Pacific-wide tsunami; and volcanic eruptions in Alaska and Hawaii. In 2016, the USGS is requesting an increase of $6.6 million to strengthen its capabilities both before and after disasters strike. Included in the request is funding to continue earthquake early warning development, continue volcano monitoring, expand the streamgage network, support solar storm monitoring, expand the Global Seismic Network, improve landslide and sinkhole understanding and response, develop a rapid response capacity for wildfires, and undertake scenario planning for disaster response. Faced with rising expectations for rapid, robust information, in response to these events, the USGS will strengthen its capabilities—both before and after disasters strike—while harnessing new technology and promoting partnerships. Efforts in 2016 will deliver science to support disaster response, provide enhanced situational awareness, provide our Nation with greater resilience to natural hazards, build on investments enacted in 2015, and significantly advance the goals outlined in the USGS Natural Hazards Science Strategy.

Natural Hazards Science for Disaster Response (+$6,618,000/+10 FTE)

Expanding Use of Flood Inundation Mapping and Rapid Deployable Streamgages	(+$700,000/+4 FTE)
Rapid Response to Volcano Unrest and Eruption, and Associated Hazards	($0/0 FTE)
Earthquake Early Warning and Rapid Event Characterization	(-$1,502,000/-2 FTE)
GSN Primary Sensor Deployment	(+$4,920,000/+2 FTE)
Improved Geomagnetic Monitoring to Support Space Weather Nowcasting	(+$1,700,000/+3 FTE)
Landslide Response	(+$500,000/+2 FTE)
Rapid Wildfire Science Response	(+$500,000/+2 FTE)
Building Sinkhole Hazard Response Capability	(+$200,000/0 FTE)
Disaster Scenarios and Strategic Science Crisis Response	(+$300,000/+1 FTE)
Precision Monitoring for Non-Seismic Fault Activity	(-$700,000/-2 FTE)

Program Performance

Expanding Use of Flood Inundation Mapping and Rapid Deployable Streamgages (+$700,000/+4 FTE)

Groundwater and Streamflow Information Program	(+$700,000/+4 FTE)

Effective flood-damage mitigation and flood response requires timely, reliable, and real-time information about river levels, flood flows, and geospatial understanding of the extent and timing of potential flood inundation, all of which the USGS is uniquely positioned to provide. From its creation, the former National Streamflow Information Program (now a component of the Groundwater and Streamflow Information Program) included provisions devoted to improve streamflow data delivery and to provide the data in context tailored to specific events and rapid assessment of streamflow conditions. The USGS, the National Oceanic and Atmospheric Administration, the Federal Emergency Management Agency, and the U.S. Army Corps of Engineers are engaged in joint efforts to standardize new flood-inundation mapping processes, enabling emergency management officials at the Federal, State, tribal, and local level to assess, in both real time and in advance, the threat that flooding poses to public facilities, businesses, and homes. For the first time, emergency officials and the general public can know the forecasted height of floodwaters, and can see on a street-by-street basis, the expected extent of a flood hours or even days before it occurs. However, these maps require extensive field data-collection to develop and calibrate. The requested increase would be used to develop and pilot such procedures and to expand the present library of flood-inundation maps based on present technologies.

Useful real-time information about flood levels can be acquired at existing USGS streamgages; however, there is an urgent need to develop the means for providing the same information to flood-threatened communities that lack a permanent USGS streamgage. Rapid-deployable streamgages (RDS) can be installed, rated, and ready to broadcast data within hours to monitor flood heights and approximate flood flows, especially as the water levels approach elevations requiring careful management of reservoir releases or close scrutiny of levee performance. The requested increase would support a focused, expansion to further test and operationalize this new technology. Implemented together, the flood-

inundation and RDS systems will provide crucial flood data needed to help manage flood response activities.

Rapid Response to Volcano Unrest and Eruption, and Associated Hazards ($0/0 FTE)

Volcano Hazards Program ($0/0 FTE)

Roughly half of the Nation's 169 volcanoes are potentially dangerous because of the manner in which they erupt and the communities within their reach. Volcano monitoring, early warning systems, and pre-crisis planning are crucial in reducing risks to aviation, communities, and infrastructure.

While no additional funding is requested in 2016, the VHP will continue 2015 investments and work to expand the development of ash-fall modeling that would give responders and the public information on when and how much ash will accumulate by continuing to expand the use of satellite-based remote sensing and infrasound detection of eruptive activity, particularly at remote volcanoes lacking ground-based instrumentation. This effort is in partnership with the National Weather Service, Air Force Weather Agency, and NASA for rapid and coordinated response to ash forming eruptions and improved delineation of ash clouds and ash fall forecasts. The VHP will continue to upgrade and improve the monitoring network at Mount Hood, a very-high-threat volcano, including installation of three more seismic monitoring stations near its summit. Mt. Hood is near Portland, OR, and is a very-high-threat ash-producing volcano.

The VHP will grow and improve the Nation’s volcano monitoring infrastructure (NVEWS) and begin efforts to install a real-time monitoring network at Glacier Peak, 70 miles northeast of Seattle, WA, with installation of ground-based instruments anticipated in 2015, and additional installations in 2016. The VHP will also complete the high-resolution lidar (3DEP) survey of Glacier Peak in support of ongoing geologic field investigations and preparation of a new geologic map of the volcano and hazard assessment. The VHP will establish permits for modern monitoring network to be installed at this volcano over the next four years. The VHP also plans to improve monitoring networks at Baker in Washington, and at Mt. Shasta and Lassen Peak in California. The VHP will repair monitoring networks on two High-Threat Alaskan volcanoes that failed due to deferred maintenance and will repair failed monitoring networks on high-threat volcanoes in the Commonwealth of the Northern Mariana Islands.

The VHP will continue long-term efforts including restoring monitoring networks on high-threat Alaskan volcanoes and redesigning networks for improved performance where possible; geologic investigations at Glacier Peak in support of a new hazard assessment; geologic investigations leading to a new hazard assessment for Mt. Shasta, a very-high-threat volcano in California; prioritizing new mapping projects in support of volcanic hazards assessments focused on very-high-threat and high-threat volcanoes; and establishing new criteria for USGS volcano hazards assessments and delivery of hazard information in digital form that is easily accessible by end users.

Earthquake Early Warning and Rapid Event Characterization (-$1,502,000/-2 FTE)

Earthquake Hazards Program (-$1,502,000/-2 FTE)

Rapid response for earthquakes and tsunamis requires improvements to the capabilities of USGS monitoring networks. These networks improve public safety and better serve the needs of decisionmakers by supporting emergency response, including the protection of critical infrastructure. The goal is to implement an earthquake early warning system along the U.S. west coast. The system will be similar to the one that has been operating successfully in Japan since 2008, and performed successfully in the 2011 M9 Tohoku earthquake. The USGS system will eventually extend to incorporate real-time deformation data from existing Global Positioning System (GPS) networks.

USGS R&D efforts in earthquake early warning (EEW) began in 2004, and a pre-prototype EEW system called *ShakeAlert* has been operating in California since January 2012. This system, which is not yet public but serves dozens of test users, was made possible by recent investments in the California Integrated Seismic Network within the USGS Advanced National Seismic System (ANSS). The USGS used American Recovery and Reinvestment Act funding to upgrade seismic and GPS networks in the State, homeland security (UASI) funds were used to upgrade the seismic network in southern California, and the Gordon and Betty Moore Foundation provided research funding to USGS partner universities. These investments have enabled earthquake detection and evaluation within seconds in some parts of the State.

Before public warnings can be issued routinely, the current *ShakeAlert* test system must meet quality, speed and reliability standards. Those standards include having enough sensors to ensure coverage near earthquake sources. Currently there are not enough ANSS sensors to provide fast and reliable alerts uniformly across the U.S. west coast. Although the Los Angeles and San Francisco Bay areas have better sensor coverage than other parts of California, it is estimated that several hundred additional stations are needed to cover all of the earthquake source regions. The USGS will work with partners, including State partners and private-sector utilities, to improve the monitoring of critical pipelines, power, and communications infrastructure systems that cross major faults.

In 2015, Congress enacted an increase of $5.0 million to the USGS, “to transition the earthquake early warning demonstration project into an operational capability on the west coast.” These funds will be used to further the ShakeAlert development effort, including the expansion of seismic network coverage that is needed to ensure accurate earthquake alerts and the integration of real-time GPS data. In 2016, at the requested funding level, USGS will work with the partners to further the development effort, with the goal of implementing a limited public warning system by 2018. These efforts will also serve to improve the ANSS as a tool to support emergency management and response by leveraging existing investments into new capabilities, including implementing and integrating response capabilities, partnering with end users to create the products they need, and building the support structure for rapid emergency response. The request for 2016 will support operational costs, providing a Federal cost share for the program. The USGS will continue to work with State partners in 2015 to identify opportunities for cost sharing agreements to support the system in their states.

GSN Primary Sensor Deployment **(+$4,920,000/+2 FTE)**

Global Seismographic Network (+$4,920,000/+2 FTE)

The Global Seismographic Network (GSN) provides high-quality seismic data needed for earthquake alerts and situational awareness products, tsunami warnings, national security (through nuclear test ban treaty verification and research), hazard assessments and earthquake loss reduction, as well as research on earthquake sources and the structure and dynamics of the Earth. The network, which the USGS jointly supports with the National Science Foundation, operating through the IRIS Consortium of universities, currently consists of more than 150 globally distributed seismic stations, installed over two decades. Network operation is accomplished in cooperation with domestic and international partners who may provide facilities to shelter the instruments, and personnel to oversee the security and operation of each station. Because of its real-time data delivery, the GSN has become a critical element of USGS hazard alerting activities, as well as of the tsunami warning system operated by the National Weather Service of NOAA.

In 2012, Congress provided $5.7 million to the Department of Energy's (DOE) National Nuclear Security Agency for the replacement of aging GSN sensors. The DOE subsequently transferred most of those funds to the USGS for the development and purchase of new borehole seismic sensors. However, under the agreement with the DOE, all of the funds were specified for procurement of the new sensors and none for installation or site improvements. Besides needing installation, one-fourth of the GSN's seismic station sites also need vault repairs to improve data quality. Until the aging sensors are replaced and vaults repaired, GSN data quality will continue to decline—as the borehole sensors fail, they are replaced by noisier surface sensors—which slowly erodes the capability of the network. Because GSN data are used for earthquake alerting (USGS), tsunami warning (NOAA), nuclear treaty verification research (DOE, DOD) and basic research on the Earth (NSF), there are many stakeholders who rely on, and have a vested interest in, the network and are anxiously awaiting this final stage of its upgrade. The requested increase covers the installation of the DOE-funded borehole sensors and repairs to 25 vaults. The resulting improvements will help ensure that the Global Seismographic Network (GSN) remains the core global system for earthquake and tsunami monitoring, nuclear treaty research and verification, Earth science and research and education.

Improved Geomagnetic Monitoring to Support Space Weather Nowcasting (+$1,700,000/+3 FTE)

Geomagnetism Program (+$1,700,000/+3 FTE)

Large magnetic storms (solar flares) represent a potential hazard for the activities and infrastructure of our modern, technologically based society, particularly due to impacts to the electrical grid. A recent study sponsored by the National Academy of Sciences estimated that the largest storm could have an economic impact of one to two trillion dollars on the United States economy. The long-term monitoring and real-time reporting of geomagnetic storms that is provided by USGS geomagnetic observatories has significant potential to advance space weather impact forecasting and research. The two most needed enhancements are in electrical field (E-field) monitoring—the direct measurement of currents in the Earth's crust—and the gathering and integration of existing global magnetic field data.

Electrical currents are induced in the Earth's crust by geomagnetic storms, which can in turn induce currents in the electric power grid that can cause the grid's massive transformers to overheat and fail or burn. Routine collection of E-field measurements are important for modeling the hazardous currents that are induced in the grid, and for assessing compliance by the electrical power industry with a recent ruling by the Federal Energy Regulatory Commission.

There is also tremendous potential represented in the global magnetic field data collected by other countries, but acquiring and managing these data and bringing the data collection efforts of many countries into the 21st century has been essentially an unfunded, volunteer effort. The interagency National Space Weather Program has given the USGS the mandate to acquire these data, and this initiative would provide the funding needed to do so. Support for one full-time technician with a travel and equipment budget could have a significant impact on global data availability. The return on that investment would be compounded in terms of both operations and research.

The USGS proposes the following investments to provide enhanced monitoring of geomagnetic- and E-field activity at ground-level:

- Expanded monitoring: Improve magnetic and electrical field monitoring by installing new observatories and variometer stations in the continental U.S., adding a Wake Island and South Pole observatory, providing support for the existing Samoan observatory, and monitoring the crustal electric field at every observatory.
- E-field monitoring: Begin a national project for detailed geographic and depth-dependent mapping of U.S.-regional lithospheric electrical conductivity, based upon magneto-telluric (MT) methods that exploit known geological structures, the existing USGS magnetic observatory network, and the network expansion proposed above.
- INTERMAGNET: Work in collaboration with academic and government institutes worldwide to integrate global observatory data with statistical and dynamical models of the magnetosphere and ionosphere to improve regional predictions of hazardous geomagnetic-field activity.
- Scenario testing: Work in collaboration with electric-power companies, the oil and gas drilling industry and the US Air Force to compile information on magnetic-storm effects and make assessments of geomagnetic hazard vulnerability and risk to technological systems and continuity of operations.

The result of these investments will be a national capability for mapping time-dependent geomagnetic hazards for assessing national space weather vulnerability and risk, with the potential for significantly improving forecasts of space weather and its impacts.

Landslide Response **(+$500,000/+2 FTE)**

Landslide Hazards Program (+$500,000/+2 FTE)

As the population moving into potentially hazardous areas grows, the overall exposure to landslide impacts rises. Changing land-use patterns and increasing wildfire frequency also contribute to an increase

in the exposure to landslide hazards. Recent landslide disasters in Colorado and Washington are stark reminders that USGS science is needed to assist State and local agencies in response efforts and to provide assistance, assess hazards, and alleviate impacts from landslides. The requested increase would build on investments in 2014 that are being used to expand post-wildfire debris flow hazard assessments and grow capability to respond to landslide crises. The USGS product for situational awareness for post-fire debris flows is comprised of two components: debris-flow hazard assessments and debris-flow warnings issued by NOAA's National Weather Service based on rainfall criteria developed by the USGS. The hazard assessment component has been expanded from southern California to the nine States of the intermountain West. However, additional resources are needed to develop rainfall criteria to support debris-flow early warning for areas beyond southern California, which requires expanded monitoring of post-wildfire landscapes. Additional funding would be used to monitor rainfall and post-fire debris-flow activity in as many as six wildfires in Arizona and Colorado. These data would support two systematic studies of rainfall conditions for post-wildfire debris-flow initiation and would be used to develop early-warning criteria for these two States. Expansion of the capability of the USGS to respond to landslide crises, such as the SR530 landslide near Oso, WA, is also needed. Additional resources would be used to develop an integrated system to monitor landslide movement and processes combining in-situ and remote-sensing observations with topographic and geologic data. This system could be deployed in response to a landslide crises in the first year of development. Results and lessons learned would be documented in a systematic study used to improve the system. Partners include NOAA, Burned Area Emergency Response teams, Federal, State and local emergency management, State geological surveys, and the private sector.

Rapid Wildfire Science Response **(+$500,000/+2 FTE)**

Environments Program (+$500,000/+2 FTE)

Wildfires continue to be an expanding natural hazard across the United States that affect human safety, landscape resilience, and infrastructure and often overwhelm effective response capacity. Accurate and timely scientific information is critical to ensure appropriate management response to wildfires and effective investments in stabilization, rehabilitation, and restoration of landscapes immediately after wildfires occur.

Currently, fire management organizations lack information to prioritize burned regions for mitigation activities. These activities focus on post-fire effects on water quality and supply, critical wildlife habitat, invasive species, and ecosystem services such as livestock grazing, timber production, and recreational value. Having this information during a wildfire allows fire managers to employ wildfire suppression strategies that result in long-term resource benefits such as reducing hazardous fuels. Demands for strategic preparation and rapid science delivery during and immediately after wildfires are increasing, and frequently surpass the current capacity for the USGS to adequately provide science for a cohesive wildfire response by Federal, State, tribal, and local organizations.

The requested increase would provide a unique opportunity for the USGS to develop a proactive rapid science response capacity for wildfires. This new capacity represents an integrated landscape-level approach that will bring together scientists from the fields of information technology, water science,

climate dynamics, ecology, geomorphology, remote sensing, risk assessment, and decision analysis. Activities will take place across scientific disciplines to ensure that consistent and comprehensive information and data products are available and that scientists are prepared, qualified, and certified to immediately respond to wildfires.

USGS scientists would develop a set of science response protocols, relevant databases, and monitoring equipment that will be easily deployed when required by wildfire response organizations, especially Federal land management agencies in the Interior and the USFS. This will fill a direct need for the USGS to support Federal wildfire-management policy by providing the scientific information and tools to ensure that fire management response planning and activities are based on the best available science. Further, this new capacity will allow real-time science support elements of the Federal Land Assistance, Management and Enhancement (FLAME) Act related to ensuring appropriate management response to wildfires and determining the most-cost effective means for allocating post-fire response investments.

Building Sinkhole Hazard Response Capability **(+$200,000/0 FTE)**

National Cooperative Geologic Mapping Program (+$200,000/0 FTE)

USGS expertise is repeatedly sought by State and local governments faced with sinkhole hazards. The requested increase would build a partnership with State geological surveys to deliver technical assistance in response to what is a widespread and at times deadly phenomenon. Recent events in Florida and elsewhere have underscored the threat that sinkholes pose in terms of loss of life and property as well as the direct and indirect costs associated with sinkhole formation. The requested increase builds on existing research activities that are making advances in understanding the geologic and hydrologic controls in sinkhole-prone landscapes, known as karst. In order to better inform and support rapid response to sinkhole formation and effective mitigation measures, this new work would focus on the short- and long-term mechanisms that trigger sinkholes, including extreme storm events, prolonged droughts leading to shifts in water management practices as well as ongoing aquifer depletion, and other major changes in water use. This work would increase areas mapped in karstic terrains. The USGS National Landslide Information Center would develop a Web portal and virtual clearinghouse for critical data needed by community planners and emergency managers.

Disaster Scenarios and Strategic Science Crisis Response **(+$300,000/+1 FTE)**

Land Change Science (+$300,000/+1 FTE)

Planning and preparing for hazard events before they strike improves response. In support of pre-event planning and preparation, the USGS will develop fully realized scenarios of disaster events in collaboration with Federal, tribal, State, local and university partners. These scenarios will improve the Nation's resilience to natural hazards, biological epidemics (e.g., epidemic avian influenza), and human triggered disasters (e.g., industrial accidents). These scenarios would apply integrated science across multiple mission areas to the intersection of community decisionmaking and emergency response. The requested increase would both expand scenario generation and fund the science gaps identified through the scenario development process. Science-based scenarios would also be developed during a crisis

response in order to reveal the impacts of alternative response strategies. Scenario development would be undertaken in partnership with the other bureaus within Interior, in consultation with the Landscape Conservation Cooperatives and the Climate Science Centers. This initiative would support a standing Interior capacity for rapidly implementing strategic science working groups, similar to what was done during the Deepwater Horizon Oil Spill disaster.

Precision Monitoring for Non-Seismic Fault Activity **(-$700,000/-2 FTE)**

Earthquake Hazards Program (-$700,000/-2 FTE)

To support higher priority efforts, the USGS will reduce efforts using two techniques for assessing fault-specific earthquake hazard: precision geodesy and active-source seismic profiling. Between the occurrences of large earthquakes, precision geodetic monitoring is used to track non-seismic fault movement. Data from this monitoring helps assess the buildup of energy along a fault, and can affect assessments of earthquake probabilities and large-earthquake recurrence times. Researchers will have to rely on less precise data, such as GPS, for fault-specific assessments. In addition, fault slip and earthquake potential are also assessed through geophysical profiling, especially seismic profiling such as is used in the oil and gas industry. Such capabilities can be used to assess fault-specific earthquake hazard. Without these data, USGS researchers will rely on geologic studies alone, significantly diminishing the understanding of individual fault geometry and slip history.

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Foundations for Land Management

Foundations for Land Management ($ in Thousands)	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Landsat Ground System	**24,300**	**0**	C-44
Land Remote Sensing	24,300	0	C-44
Ecosystem Services	**1,750**	**5**	C-45
National Ecosystems Framework	**450**	**0**	C-46
Environments Program	450	0	C-46
Biological Carbon Sequestration	**400**	**2**	C-46
Carbon Sequestration	400	2	C-46
Landscape and Climate Conditions	**200**	**1**	C-46
Land Change Science	200	1	C-46
Evaluating Green Infrastructure Investments	**250**	**1**	C-47
Energy Resources	250	1	C-47
Enhancing Resiliance in Coastal Infrastructure	**150**	**1**	C-47
Energy Resources	150	1	C-47
Decision Support Tools	**300**	**0**	C-47
Science Synthesis, Analysis and Research Program	300	0	C-47
Big Earth Data	**1,100**	**0**	C-48
Data Cube	**600**	**0**	C-48
Land Remote Sensing	600	0	C-48
Observations and Measurements	**500**	**0**	C-49
Science Synthesis, Analysis and Research Program	500	0	C-49
Landsat Science Products for Climate and Natural Resources Assessments	**4,000**	**2**	C-49
Land Remote Sensing	4,000	2	C-49
National Civil Applications Program	**-1,000**	**-5**	C-49
Land Remote Sensing	-1,000	-5	C-49
3D Elevation Program	**3,709**	**3**	C-50
National Enhancement	**1,387**	**0**	C-51
National Geospatial Program	1,387	0	C-51
Alaska Mapping and Map Modernization	**1,322**	**3**	C-51
National Geospatial Program	1,322	3	C-51
NHD/Landscape Level Assessments - Chesapeake Bay	**500**	**0**	C-51
National Geospatial Program	500	0	C-51
Coastal Lidar	**500**	**0**	C-52
National Geospatial Program	500	0	C-52
Great Lakes Fisheries Assessments	**250**	**0**	C-52
Fisheries Program	250	0	C-52
Enhanced Cooperative Activities and Urban Waters	**717**	**5**	C-53
National Water Quality Program	717	5	C-53
Outer Continental Shelf (OCS) Ecosystems Decisions	**300**	**2**	C-54
Environments Program	300	2	C-54
Enhanced Support and Scientists for Tomorrow	**2,000**	**9**	C-54
Cooperative Research Units	2,000	9	C-54
Emerging Contaminants and Chemical Mixtures	**700**	**4**	C-55
Toxic Substance Hydrology	700	4	C-55
Grand Total	**37,826**	**25**	

Justification of 2016 Program Changes (+$37,826,000/+25 FTE)

Landsat Ground System	(+$24,300,000/0 FTE)
Ecosystem Services	(+$1,750,000/+5 FTE)
Big Earth Data	(+$1,100,000/0 FTE)
Landsat Science Products for Climate and Natural Resource Assessments	(+$4,000,000/+2 FTE)
National Civil Applications Program	(-$1,000,000/-5 FTE)

3D Elevation (3DEP) Program	(+$3,709,000/+3 FTE)
Great Lakes Fisheries Assessments	(+$250,000/0 FTE)
Enhanced Cooperative Activities and Urban Waters	(+$717,000/+5 FTE)
Outer Continental Shelf (OCS) Ecosystems Decisions	(+$300,000/+2 FTE)
Enhanced Support and Scientists for Tomorrow	(+$2,000,000/+9 FTE)
Emerging Contaminants and Chemical Mixtures	(+$700,000/+4 FTE)

Overview

Foundational to all work in landscapes and across the other science themes are data and tools. These data and tools help land and resource managers make informed decisions across the landscape and provide data and information to the public for use in a wide variety of applications. This component expands efforts in lidar collection for 3D elevation, Big Earth Data, development of Landsat science products, ecosystem services, and building the next generation of natural resource scientists and managers. Continuing the Landsat data stream by initiating the next Landsat ground system for the Thermal Instrument Free Flyer, Landsat 9, and to receive and disseminate Sentinel-2 data is also requested. The Foundations for Land Management component supports implementing the Administration's Open Data Initiative including the Open Water Initiative and Big Earth Data Initiative and makes tools available to communities and government entities which support the Secretary's Mitigation Strategy. These data and their access are required to support Presidential and Secretarial priorities for Building a Landscape Level Understanding of Our Resources.

Program Performance

Landsat Ground System (+$24,300,000/0 FTE)

Land Remote Sensing	(+$24,300,000/0 FTE)

In 2016, the USGS Landsat satellite program is requesting to be funded at $77.6 million, $24.3 million above 2015, and includes funding for the maintenance and operation of ground systems and satellite operations. Following extensive study, the Administration has established a plan for a long-term Sustainable Land Imaging program that would extend the four-decade long Landsat series of measurements of the Earth's land surfaces for another two decades. The plan includes three simultaneous activities: a new U.S.-built small satellite with a thermal imager that would launch as soon as feasible, likely in 2019, and would operate either in conjunction with a European Sentinel-2 satellite or with the Landsat 8. The second activity would be the initiation of Landsat 9 as a rebuild of Landsat 8, with a target launch date in early 2023. The third activity is ongoing investment in technology development and systems innovation to reduce risk in next generation missions, including Landsat 10.

The requested increase in 2016 is the first time the USGS will be requesting new funding to build capacity to operate the satellites and collect, archive, process and distribute the data for the Sustainable Land Imaging program. Additional funding requests will be made in future fiscal years. In 2016, the USGS would document the space and ground segment requirements and define specifications for instrument procurements, provide engineering support and technical assistance in the evaluation and

selection of NASA's spacecraft, and in evaluating competitive contract proposals for needed functionality. The USGS will work with NASA to carry out this program. During 2016, the USGS will support NASA mission systems engineering activities, including: space-to-ground interface design, mission operations concept establishment, system component integration definition, development of verification plans for system testing, instrument calibration and validation engineering, support of instrument specifications and requirements definition, and building and evaluating requests for proposals. Finally, the USGS will develop and refine ground-system operations concepts and requirements, perform ground system design activities with an emphasis on the space-to-ground interface, and formulate acquisition strategies for ground network, data processing, and mission operations center (flight systems and software) capabilities.

Additionally in 2016, the USGS would establish the capability to acquire, store, and disseminate data from the European Space Agency's Sentinel-2 satellites (Sentinel 2A is expected to launch in 2015 and Sentinel 2B in 2016). Sentinel-2 data may partially mitigate the risk of losing the eight-day revisit coverage during the period between the decommissioning of Landsat 7 and the launch and operations of a Landsat 8 Rebuild mission.

Ecosystems Services (+$1,750,000/+5 FTE)

National Ecosystems Framework	(+$450,000/0 FTE)
Biological Carbon Sequestration	(+$400,000/+2 FTE)
Landscape and Climate Conditions	(+$200,000/+1 FTE)
Evaluating Green Infrastructure Investments	(+$250,000/+1 FTE)
Enhancing Resilience in Coastal Infrastructure	(+$150,000/+1 FTE)
Decision Support Tools	(+$300,000/0 FTE)

Overview

Land and resource management agencies are increasingly being called upon to understand the effects of their actions in an economic context. Tools, data systems and methods must be developed to achieve a comprehensive understanding of the effects of management actions so that decisions factor in effects on essential environmental benefits. Once these tools are readily available, a formal mechanism or capability to routinely integrate these sources of information into valuation assessment products for land and resource management is needed. Data from multiple monitoring programs are being gathered in EcoINFORMA and other data hubs. Tools are being gathered and developed and their uses standardized. The framework for using those tools and data in decisionmaking contexts are being developed in the National Ecosystem Services Framework and the National Map of Areas of Concern. Information for particular services and stressors such as carbon sequestration and climate are also included in this group of initiatives.

Program Performance

National Ecosystems Framework **(+$450,000/0 FTE)**

Environments Program (+$450,000/0 FTE)

Many services of natural systems are difficult to quantify and therefore are not well considered in decisionmaking. As part of a multiagency assessment of biodiversity and ecosystem services trends, the USGS evaluates data, information, methods, and tools that contribute to the identification, assessment, valuation and use of ecosystem services for policy and management scenarios. In 2015, the USGS will support cross-government leadership, coordination, and studies that focus on integrating ecosystem services assessment into Federal decisionmaking to ensure that benefits to society are fully considered. The 2016 increase will allow the USGS to expand this work. The USGS will assess and fill additional information gaps; test protocols for integrating interagency information in natural resource assessments, and refine interagency practices for applying information in natural resource decisionmaking. This activity contributes to the goals of the Committee on Environment, Natural Resources and Sustainability's Subcommittee on Ecological Systems and other cross-government efforts to develop policy-relevant information on ecosystem services for Federal decisionmaking.

Biological Carbon Sequestration **(+$400,000/+2 FTE)**

Carbon Sequestration (+$400,000/+2 FTE)

The biological carbon sequestration project (LandCarbon) develops tools to analyze how land management actions may be affecting rates of carbon sequestration and other ecosystem services. With additional funding, an existing pilot study with the U.S. Fish and Wildlife Service at the Great Dismal Swamp and Pocosin Lakes National Wildlife Refuges will be expanded to include a study in the Pacific Northwest with the National Park Service (e.g., Olympic National Park), where park managers and other stakeholders can explore alternative management strategies and their potential impact on services such as carbon sequestration, water quality, and biodiversity. Various mitigation scenarios would be explored, including expanding conservation areas and management practices; increasing intensive forest management; and enhancing ecosystem resilience to reduce emissions of carbon dioxide. USGS scientists have developed methods to incorporate Landsat satellite data, collect stakeholder input, and develop models and tools. Interagency agreements and partnerships would be developed to ensure practical uses in day-to-day land management decision making.

Landscape and Climate Conditions **(+$200,000/+1 FTE)**

Land Change Science (+$200,000/+1 FTE)

The Land Change Science (LCS) Program proposes to develop decision-support tools that could be used to help synthesize, visualize, and analyze ecosystem services. The LCS Program would establish methodologies for the assessment and mapping of ecosystem goods and services, and contributing to their valuation, with an emphasis on understanding how they respond to changing landscape and climatic

conditions. These tools translate knowledge gained through a variety of case studies into standardized thematic information, metrics, models, and tools that facilitate improved decisionmaking by natural resource managers. The LCS Program will develop these tools for some of the USGS priority landscapes: the Everglades; San Francisco Bay-Delta; Sage steppe Biome; Colorado River; Puget Sound; Great Lakes; and Chesapeake Bay, which require tools supporting critical management decisions.

Evaluating Green Infrastructure Investments **(+$250,000/+1 FTE)**

Energy Resources (+$250,000/+1 FTE)

The issue of valuing ecosystem services is critical to our Nation's ability to make informed decisions in managing biological, water, and geologic natural resources. Since many ecosystem services are public goods, markets do not provide meaningful indications about the value of these services. The USGS Science and Decisions Center proposes to refine and apply methods of valuing ecosystem services, and evaluating green (nature based) infrastructure investments, especially in Critical Landscapes. These activities focus on methods of applying ecosystem service valuations to inform decisions and will support implementation of the President's Council on Science and Technology Advisors (PCAST) report, "Sustaining Environmental Capital: Protecting Society and the Economy."

Enhancing Resilience in Coastal Infrastructure **(+$150,000/+1 FTE)**

Energy Resources (+$150,000/+1 FTE)

An ecosystem services approach provides an analytical framework for considering the impacts of climate change on services provided by nature as well as manmade. The Science and Decisions Center would use the requested funds to build on a multiagency effort to advance the use of an ecosystem services approach in informing climate change adaptation and decisions. The effort would address issues related to metrics, valuation and institutional factors in order to inform adaptation decisions.

Decision Support Tools **(+$300,000/0 FTE)**

Science Synthesis, Analysis, and Research (+$300,000/0 FTE)

The USGS would use geospatial analyses and synthesis of existing data to identify regional areas of conservation concern, quantified through ecosystems services, to produce a national-scale map highlighting areas of concern. The USGS would identify possible mitigation strategies for each regional area of concern by aligning management actions to policy outlined in law or regulation. Spatial output would be quickly revised to adapt to changing policy concerns. The national-scale map of areas of concern would be a key tool for managers to successfully evaluate at-risk resources and enhance mitigation success. The Wyoming Landscape Conservation Initiative Integrated Assessment (*https://www.wlci.gov/wlciIA/*) provides a multifactorial index identifying watersheds where conservation actions may be more or less-effective; provide building blocks for this approach toward a national scale capability.

Big Earth Data (+$1,100,000/0 FTE)

Data Cube	(+$600,000/0 FTE)
Observations and Measurements	(+$500,000/0 FTE)

Overview

The overall goal of the Big Earth Data Initiative (BEDI) is to increase discoverability, accessibility, and usability of high value Earth observations with a particular focus on the Climate Data Initiative and other national science and decisionmaking priorities. In 2013, strategic direction was established by developing the National Plan for Civil Earth Observations, the BEDI Common Framework, and coordinated implementation plans in the USGS, the National Oceanic and Atmospheric Administration (NOAA), and NASA. These plans directly support the Office of Science and Technology Policy's Open Data initiatives on open access to research, the Executive Order and OMB Memorandum 13-13.

An increase of $2.0 million was enacted in 2015 to support BEDI and Interior-wide coordination efforts, continuing to improve Earth science data discovery and begin efforts to improve accessibility. In 2016, the USGS will continue to lead the USGEO to advance BEDI; implement and populate the USGS Science Data Catalog; apply USGS science data management policies to datasets; implement tools that make it easier for scientists to document their data; integrate individual datasets into larger portal platforms (e.g., the National Geospatial Platform, EcoINFORMA, etc.); and begin to develop Web services for high-priority datasets.

Program Performance

Data Cube **(+$600,000/0 FTE)**

Land Remote Sensing	(+$600,000/0 FTE)

The Land Remote Sensing (LRS) Program would initiate the development of a pilot study for Landsat data access that would allow the user to define a geographic area of interest, timeframe, and specific parameters derived from the data (e.g., vegetation index) rather than the pre-determined geographic extent and digital numbers currently provided by the USGS. The USGS currently requires users to perform the framing, subsetting, and computing of derived information on their own. The LRS program would prototype these streamlined data access capabilities to demonstrate the utility and efficiency of direct access to "pixels of interest." The prototype capability would allow the USGS to demonstrate the ability to extract and create a multi-temporal remote sensing based value-added product(s), or "data cube(s)," which will be "applications ready" for use in support of scientific analysis.

Observations and Measurements **(+$500,000/0 FTE)**

Science Synthesis, Analysis, and Research (+$500,000/0 FTE)

As a contribution to the Climate Data Initiative, the USGS would develop Web services that will apply the Observations and Measurements Data Model, an International Standards Organization standard, on priority climate data. This effort would provide an application that makes it easier for scientists and others to access, integrate, and apply their information. Leveraging the National Geospatial Platform, this effort would increase the availability of USGS climate data that is required to support more informed landscape level decisionmaking. The USGS has requested an increase in 2016 for the Community Resilience Toolkit. The Toolkit creates a clearinghouse where BEDI data and information could be made available.

Landsat Science Products for Climate and Natural Resources Assessments (+$4,000,000/+2 FTE)

Land Remote Sensing Program (+$4,000,000/+2 FTE)

The requested increase will be used to increase the usability and impact of Landsat science products for climate studies and land management. The Interior bureaus rely on Landsat as a data source on wildfires, consumptive water use, land cover change, rangeland status, wildlife habitat, and other Interior responsibilities. Landsat 8 is a $1.0 billion Federal investment and has improved data quality, particularly for snow- and ice-covered land surfaces, water resources monitoring and resource management. The requested increase would allow the LRS Program to accelerate the development of Landsat-based science information products. The LRS Program has identified a set of Landsat-based science products that will improve applications used by natural resource managers, and will contribute to the international and interagency climate monitoring community's initiative to develop consistent Climate Data Records (CDRs) and related Essential Climate Variables (ECVs). The CDRs are long-term time-series measurements such as surface reflectance that support a variety of ECVs, including measures of fire disturbance, snow cover, permafrost, surface water extent, land cover, and biomass. The CDRs and ECVs will provide an authoritative basis for regional- to continental-scale identification of historical change, monitoring of current conditions, and predicting future scenarios. The requested increase would drive a focus on augmenting computing and online storage resources, generation of CDR and ECV products from the historical archive for the conterminous United States and Alaska, and implementation of enhanced continuation of the CDR and ECV product generation to include near real time processing of current acquisitions and completion of enhanced data access and delivery services.

National Civil Applications Program (-$1,000,000/-5 FTE)

Land Remote Sensing Program (-$1,000,000/-5 FTE)

The National Civil Applications Program (NCAP) uses data from classified systems and commercial satellites to investigate climate change and other Earth dynamics, ecosystems, natural hazards, and

manmade disasters (such as wildland fires), and improve land and resources management. In 2016 the Land Remote Sensing Program will begin to decrease lower-priority, outdated, or duplicative functions of the NCAP. The USGS will maintain its civil science leadership of the Civil Applications Committee and assess ways to use classified assets for hazards, environmental, and natural resources applications strategically. In addition, USGS NCAP funding for research will be leveraged to maximize cost-sharing with other agencies. The acquisition, archive, and dissemination of classified remotely sensed data to support science programs of the USGS, Interior, and other Federal civil agencies would be continued.

3D Elevation Program (+$3,709,000/+3 FTE)

National Enhancement	(+$1,387,000/0 FTE)
Alaska Mapping and Map Modernization	(+$1,322,000/+3 FTE)
NHD/Landscape Level Assessments – Chesapeake Bay	(+$500,000/0 FTE)
Coastal Lidar	(+$500,000/0 FTE)

Overview

Prompted by a growing appreciation for the wide applicability and inherent value of lidar, a USGS-led consortium of Federal agencies commissioned a National Enhanced Elevation Assessment (NEEA) study in 2010 to quantify the costs and benefits of a national lidar program. A 2012 NEEA report documented a substantial return on such an investment, defined five Quality Levels (QL) for elevation data, and recommended an 8-year collection cycle of Quality Level 2 (QL2) lidar data as the optimum balance of benefit and affordability. In response to the study, the USGS–NGP established the 3D Elevation Program (3DEP) in 2013 as the interagency vehicle through which the NEEA recommendations could be realized.

3DEP activity responds to growing needs for high-quality and high-resolution elevation data to capture change in the Nation's natural and constructed features. New and accurate data are constantly in demand to improve aviation safety, understand and mitigate the negative effects of coastal erosion and storm surges, provide infrastructure for Arctic shipping and resource extraction, identify landslide hazard areas, protect biodiversity and habitats, and to support hundreds of other mission critical activities within Interior and other Federal, State, and tribal partners. The 3DEP initiative will systematically collect and make available 3D elevation data using lidar (light detection and ranging) over the United States. Ifsar (Interferometric Synthetic Aperture Radar) data would be collected in Alaska. These data would directly contribute to the Secretary’s priorities for Landscape Scale Understanding, improving the lives of Native Americans, WaterSMART, and America’s Great Outdoors.

Potential benefits of $1.2 billion to $13.0 billion would accrue annually to the Nation from 3DEP data. The current project-by-project Federal approach to acquire these data yields fewer than 10 percent of these benefits. The 3DEP replaces the current approach with a coordinated data acquisition campaign to provide national data coverage and related products and services. This effort would increase the benefits realized from 10 percent to as much as 58 percent. Key activities include: (1) a national Federal and State partnership data acquisition campaign to lower acquisition costs per square mile and to increase data collection coverage from 5–12 percent of the United States annually; (2) increasing the quality of data acquired to benefit a larger number of business needs; and (3) providing application ready products and

services for lidar point-cloud and bare-Earth elevation data and derived products that support the most common business applications.

Program Performance

National Enhancement **(+$1,387,000/0 FTE)**

National Geospatial Program (+$1,387,000/0 FTE)

The USGS would accelerate its collection by 4,140 square miles of QL2 lidar per year over the remaining States, Puerto Rico, and District of Columbia, with expectations to leverage with other State and Federal sources, resulting in 12,420 square miles per year. The requested increase would expand the current coverage rate of data collection from approximately 5 percent of the Nation per year to about 5.5 percent per year.

Additional 3DEP Efforts:	
Columbia River	+$350,000
Puget Sound	+$450,000
Chesapeake Bay	+$500,000

Alaska Mapping and Map Modernization **(+$1,322,000/+3 FTE)**

National Geospatial Program (+$1,322,000/+3 FTE)

The requested increase would enable the USGS to collect 6,100 square miles of new ifsar over Alaska each year, with expectations to leverage those funds from other State and Federal sources up to three times, for a resulting combined 18,300 square miles per year. The requested increase would allow for new tools to integrate elevation data with surface water information, transportation, boundaries, and manmade structures and provide easier access and downloading capabilities, and improved Web services.

NHD/Landscape Level Assessments – Chesapeake Bay **(+$500,000/0 FTE)**

National Geospatial Program (+$500,000/0 FTE)

The USGS would systematically collect and manage high-quality lidar over the eastern shore of the Chesapeake Bay. This 65,000 square mile drainage basin is the largest estuary in the United States and touches six States and the District of Columbia. New and accurate baseline elevation data are required to understand landscape level processes at a parcel and local level scale and to develop strategies that allow for the Bay's sustainable development and management of natural resources. To achieve this objective, the USGS will need to increase its commitment to elevation data collection and management and to the National Hydrographic Dataset. Ongoing Federal and State lidar acquisition partnerships throughout the Chesapeake Bay watershed would be leveraged and expanded.

Coastal Lidar **(+$500,000/0 FTE)**

National Geospatial Program (+$500,000/0 FTE)

The National Geospatial Program would use the requested increase to collect enhanced elevation data using lidar in coastal zones over the United States. New and accurate baseline elevation data is required to understand and mitigate the negative effects of coastal erosion and storm surge, to map existing and potential landslide hazards, and to monitor biomass in a changing world. The 3DEP within the NGP responds to growing needs for high-quality and high resolution topographic data to capture change in the Nation's natural and constructed features and would be used for sea-level rise modeling projects in the Coastal and Marine Geology Program.

Great Lakes Fisheries Assessments (+$250,000/0 FTE)

Fisheries Program (+$250,000/0 FTE)

As recognized by the President's Great Lakes Restoration Initiative, the Great Lakes are a key strategic resource and driver of economic vitality that are threatened by multiple stressors that include invasions of exotic mussels and fishes, habitat degradation, and harmful algal blooms. The USGS is hard-pressed to meet the information needs of our regional management partners due to the sheer scope of imposed ecological changes. Spatially comprehensive and resolute information through time is needed about the drivers of changes to deep-water fisheries, coastal ecosystems, and beach health to guide the implementation of effective interventions. The rapid advancement of 21st century tools, technologies, and science presents our best hope for gathering information that matches the scope of the challenges. The USGS proposes to further the use of advanced technologies in the Great Lakes in the following areas:

- Understanding lake-scale implications of invasive mussels for deepwater fish production by understanding how mussels affect biomass and size spectra of lower trophic levels
- Developing a mechanistic understanding of how climate, nutrients, and lake morphology interact to affect harmful algae blooms
- Piloting an early warning system for detection of human pathogens that cause millions of dollars in annual economic losses to the U.S. coastal tourism industry

Long Range Autonomous Underwater Vehicles (LR AUVs) would be used to assess biomass size spectra over large spatial scales to enable extensive estimation of total fish biomass in the Great Lakes. LR AUVs are unmanned and untethered vehicles that help remove the high personnel costs of scientific sampling in very deepwater environments. These platforms are low cost as compared to ships but can be directed as to where, when, and what they sample to full lake or ocean depth. This work will provide new insight into impacts of invasive mussels on Great Lakes fish production, as well as new information that could impact critical annual decisions by fisheries managers. The work will be carried out in collaboration with the Monterey Bay Aquarium Research Institute (MBARI), a privately funded NGO, and the Michigan Technical University (MTU).

Sample Processors (ESP) would provide onsite (in situ) collection and analysis of water samples from the subsurface Great Lakes. The instrument is an electromechanical/fluidic system designed to collect discrete water samples, concentrate microorganisms or particles, and automate application of molecular probes that identify microorganisms and their gene products. The ESP also archives samples so that further analyses may be done after the instrument is recovered from the lake or ocean floor. Specifically, the ESP will be used to automatically monitor phytocyanin concentrations in Great Lakes waters, exploring the role of those organisms in the development of Harmful Algal Blooms (HABS). The recent explosion of HABs in the Great Lakes is linked to significant environmental, economic, and health concerns across the Great Lakes basin and communities.

A pilot project using ESPs offshore from Chicago, IL, beach sites would provide an early warning system for health decisionmaking. Major human health threats are arising from naturally occurring toxicants and anthropogenically derived environmental contaminants at those very heavily used public beaches.

Enhanced Cooperative Activities and Urban Waters (+$717,000/+5 FTE)

National Water Quality Program (+$717,000/+5 FTE)

The requested increase for the National Water Quality Program would enhance cooperative activities related to energy and water; enhance local cooperative studies related to regional drought; enhance data collection related to tribal water issues. The National Water Quality Program would be able to support monitoring streamgages, groundwater levels, and water-quality observations at 2015 levels.

In addition, the National Water Quality Program would fund activities in the Urban Waters Federal Partnership (UWFP). Urban waters in rivers and lakes commonly have degraded water quality that is not suitable for drinking, swimming, or fishing. Contaminants, habitat destruction, and increasing streamflow flashiness (rate of change of stream discharge) resulting from urban development have been associated with the disruption of biological communities, particularly the loss of sensitive biota. Every stream is connected downstream to other water bodies, and inputs of contaminants and/or sediments to streams can cause degradation downstream with adverse effects on biological communities and on economically valuable resources, such as fisheries and tourism. In addition, stormwater runoff is a major problem in urban areas, increasing contaminant loads in local streams and rivers and costing cities millions of dollars to mitigate. Economic revitalization and economic development through urban water restoration is an important component of the UWFP. Through the National Water Quality Program, localities and States are engaged as they are concerned with similar issues to better protect their urban watersheds, resulting in jointly planned and jointly funded activities that align with and leverage the national goals for the programs. Funding would provide new streamgages or upgrade existing streamgages; enhance water quality, water quantity, and habitat monitoring; support studies to understand the use of nature based infrastructure to reduce the impact of stormwater runoff; and to develop modeling tools to simulate water quality, biological conditions, and to describe stream health. New multi-stressor models would provide insight on how management actions can improve water quality, flow characteristics, habitat, and biological conditions.

Outer Continental Shelf (OCS) Ecosystems Decisions (+$300,000/+2 FTE)

Environments Program (+$300,000/+2 FTE)

The coastal and offshore environment is increasingly being seen as an opportunity for renewable resource development, substantially ramping up the need for biological science to support decision needs of Interior bureaus. USGS research has a unique role in marine waters to support, in particular, BOEM mission-critical research priorities focused on Interior trust resources (sea birds, marine mammals, aquatic ecosystems) and potential impacts of energy development on wildlife, their habitats, and the coastal ecosystem resilience. Continued long-term research, supported by short-term focused research, is needed across multiple disciplines. This includes investigations as diverse as predicting the response of polar bears and walrus to sea ice declines, mapping of seabird abundance and distribution, understanding benthic resources and microbial ecology, determining acoustic effects on marine animals, and charting deep sea coral distributions and function. The proposed increase would provide the USGS with resources to develop a comprehensive geographic dataset on the pelagic distribution and movements of seabirds in the U.S. Pacific Ocean using methodology developed for the Atlantic, to design long-term research and monitoring strategies to understand ecosystem changes in relation to wildlife resources, and to expand investigations on offshore wind energy and wildlife on the Atlantic coast. Research will be coordinated closely with BOEM to identify the most effective science projects. This will result in improved study planning and implementation mechanisms to enhance the Outer Continental Shelf (OCS) program results overall.

Enhanced Support and Scientists for Tomorrow (+$2,000,000/+9 FTE)

Cooperative Research Units (+$2,000,000/+9 FTE)

Youth Scientists for Tomorrow– The Cooperative Research Units (CRU) involvement in youth programs has traditionally been focused on graduate education. CRU will apply the requested increase to implement two initiatives that provide undergraduate students, from groups under-represented in the conservation workforce, with mentoring and hands-on experience designed as a pathway to Interior recruitment. The CRU Program will use its existing cooperative network to work with Interior partners to improve and increase youth involvement in Interior science and resources management.

- The first initiative will be in collaboration with the Doris Duke Foundation. Undergraduate students at five CRU host universities will be mentored by CRU supported graduate students and research scientists. Students will attend leadership training programs, work with scientists and graduate students on selected research projects, and complete paid internships with local, State, Federal, and tribal agencies or Nongovernmental Organizations (NGOs). Increase will be used to support internships and staff time.
- The second initiative will be in collaboration with the FWS. Funding will support graduate and undergraduate students conducting research on National Wildlife Refuges as a means to develop and recruit Federal scientists and natural resource managers. Students will address research topics of importance to the USGS and the National Wildlife Refuge System including landscape connectivity, fish and wildlife health, human uses, and wildlife population management.

The proposed increase would enhance opportunities to provide advanced scientific training and professional mentorship leading to Masters and PhD. Funding will focus on the training of students on contemporary research topics including the application of science and analytical tools for decisionmaking, energy development, fire ecology, ecosystem sustainability, threatened and endangered species, invasive species, and water quality and use. Student support includes safety training and equipment in addition to financial and research support. Implementation will be through enhancement of existing partnerships with universities and NGOs serving Native American and Hispanic communities and other underrepresented groups.

Science, technology, engineering, and mathematics (STEM) - The CRU program engages in scientific research, technical assistance to natural resource managers, and training of future natural resource professionals. The CRU will apply the requested increase towards training, mentoring, and support of STEM graduate and post-doctoral associates from under-represented groups. Unit scientists are particularly poised to advise and mentor STEM graduate students, and the requested increase will expand capacity and provide focus on minority recruitment. Students will address thematic science of importance to the USGS and Interior bureaus including the application of science and analytical tools for decisionmaking, energy development, fire ecology, ecosystem sustainability, threatened and endangered species, invasive species, and water quality and use.

Emerging Contaminants and Chemical Mixtures (+$700,000/+4 FTE)

Toxic Substances Hydrology Program (+$700,000/ +4 FTE)

The requested increase will support a national assessment of contaminant mixtures at stream locations affected by combinations of contaminant sources, including wastewater treatment plant discharges, industrial discharges, landfill leachate, crop agriculture, and animal agriculture. Samples of stream waters and sediments have been collected in 2014, will be analyzed in 2015, and using USGS analytical capabilities for approximately 800 common and emerging chemical contaminants. In addition, the USGS will employ extensive forensic analyses to identify unknown contaminants in these environmental samples. This project is being coordinated with the EPA and their capability to conduct *in vitro* bioassays of environmental samples. The information produced by these activities can provide a basis for toxicity testing for chemical mixtures and low-level exposures; help improve understanding groups of contaminant effects on organism health; and identify unidentified contaminants of emerging concern based their actual presence and their levels in the environment. A pilot project, completed in 2014, tested chemical mixtures and forensic methods in stream waters at a limited number of stream sites; scientists from the EPA National Exposure Research Lab, National Risk Management Research Lab, and National Health and Environmental Effects Research Laboratory are testing the same water samples for biological activity using bioassays. The expanded effort will enable interpretations of the existing chemical and bioassay data.

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Climate Resilience

Climate Resilience ($ in Thousands)	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Carbon Sequestration	**8,700**	**21**	C-58
Biological Carbon Monitoring and Tools	**6,500**	**15**	C-58
Carbon Sequestration	6,500	15	C-58
Biological Carbon Sequestration Land Management	**200**	**1**	C-58
Carbon Sequestration	200	1	C-58
Grand Challenge: Carbon Inventory and Decision Support Tools	**2,000**	**5**	C-58
Carbon Sequestration	2,000	5	C-58
Adaptation and Resilience	**6,818**	**13**	C-60
Climate Adaptation and Resiliency - Vulnerability Assesment Database	**800**	**0**	C-60
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	800	0	C-60
Emerging Science Needs	**2,268**	**6**	C-60
Climate Research & Development	2,268	6	C-60
Grand Challenge: Climate and Land Cover Change Effects	**1,500**	**3**	C-60
Climate Research & Development	1,500	3	C-60
Interagency Coordination	**2,250**	**4**	C-60
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	2,250	4	C-60
Community Resilience and Partnerships	**16,500**	**2**	C-62
Community Resilience Toolkit	**11,000**	**0**	C-63
National Geospatial Program	11,000	0	C-63
Translational Science Grants	**3,000**	**2**	C-65
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	3,000	2	C-65
Tribal Climate Science Partnerships	**2,500**	**0**	C-66
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	2,500	0	C-66
Grand Total	**32,018**	**36**	

Justification of 2016 Program Changes (+$32,018,000/+36 FTE)

Carbon Sequestration	(+$8,700,000/+21 FTE)
Adaptation and Resilience	(+$6,818,000/+13 FTE)
Community Resilience and Partnerships	(+$16,500,000/+2 FTE)

Overview

The effects of changing climate are most profound in the frequency and intensity of extreme weather events. USGS scientists are conducting science to understand the impacts of these events and are building tools for communities and land and resource managers to use in building resilience to and adapting after these events. In 2016, the USGS will expand partnerships and collaboration, translate science into practical application-ready solutions, initiate new science activities in emerging areas such as integrating long historical records into climate modeling, establish a national carbon inventory and tracking system, and building a clearinghouse of data, tools, shared applications, and best practices for use by resource managers, decisionmakers, and the public.

Program Performance

Carbon Sequestration (+8,700,000/+21 FTE)

Biological Carbon Monitoring and Tools	(+$6,500,000/+15 FTE)
Biological Carbon Sequestration Land Management	(+$200,000/+1 FTE)
Grand Challenge: Carbon Inventory and Decision Support Tools	(+$2,000,000/+5 FTE)

Program Performance

Biologic carbon sequestration refers to both natural and deliberate processes by which carbon dioxide (CO_2) is removed from the atmosphere and stored as carbon in vegetation, soils and sediments. The President's Climate Action Plan (June 2013) notes the importance of biological carbon sequestration: "America's ecosystems are critical to our Nation's economy and the lives and health of our citizens. These natural resources can also help ameliorate the impacts of climate change, if they are properly protected." Congress, too, recognized its importance, mandating a national inventory of carbon sequestration and greenhouse gas fluxes under section 712 of the Energy Independence and Security Act of 2007.

Management of carbon stored in biological reservoirs has importance for both mitigation of climate change and for adaptation to such changes. The USGS has developed methods for evaluating biological carbon storage at a regional scale; however, these methods were developed for a broad national assessment and need refinement to be applicable to a specific site or decision. The development of an approach that identifies the scientific basis for carbon management decisions (such as ecosystem restoration) and a process to incorporate science information directly in management planning will be critical to ensure effective use of scientific results. While management activities have implications for carbon management, informed decisions are often hampered by the lack of tools for understanding or incorporating science into decisionmaking. The USGS will work directly with decisionmakers to understand their needs and timelines, and develop and apply refined geospatial models and estimation techniques for biological carbon sequestration, as well as decision-support tools supporting carbon management objectives and the tradeoffs involved with other ecosystem services. In 2016, the biological carbon sequestration project would develop methodologies for updating critical input data, streamline biogeochemical models for calculating carbon stocks and sequestration, and engage an interdisciplinary team of scientists for evaluating and documenting results. The project would also conduct research and development for reducing carbon stock and sequestration uncertainties. Further research into quantifying and reducing uncertainties in estimating carbon stocks and sequestration is needed to incorporate information on carbon stocks and sequestration into land management decisions and national and global policy development.

The biological carbon sequestration national assessment will be completed in 2015 for all 50 States. In 2016, the biological carbon sequestration project would initiate a grand challenge leveraging this initial assessment to implement a carbon inventory and tracking system for carbon stocks and flows on all Interior lands, complete with online tools to support regional natural resource decisionmaking.

Interior can be a leader in the Federal Government in establishing a national carbon inventory and tracking system. Interior manages one-fifth of the Nation's lands; on those lands, the BIA, BLM, FWS, NPS, and Office of Wildland Fire have a shared need to incorporate into their resource management decisions both current science and regional stakeholders' values for uses (ecosystem services) of the land, ranging from recreation to carbon management. These science and stakeholder inputs are needed to support resource managers in planning infrastructure investments for resilience to extreme weather and changing climate, in forest planning and supporting Tribal forest management, and in assessing the impacts of activities such as wildfire fuels treatments.

The implementation of the *Priority Agenda on Enhancing the Climate Resilience of America's Natural Resources* (www.whitehouse.gov/sites/default/files/docs/enhancing_climate_resilience_of_americas_natural_resources.pdf) presents an opportunity to broaden and accelerate existing work to support these goals. Interior proposes to leverage multiple bureaus' expertise and authorities to:

- Improve inventory, assessment, projection, and monitoring systems for important carbon sinks.
- Develop estimates of baseline carbon stocks and trends to inform Federal natural resources management.
- Assess, restore, and protect coastal habitats to understand and enhance the storage of blue carbon.
- Incorporate carbon into natural resource management practices.

These efforts will be integrated into accelerated work on quantifying ecosystem services for Federal lands. The results will be used to enhance existing online decision support tools with new content, building on the USGS LandCarbon Viewer to develop a comprehensive resource for managers on the ground. Work will be conducted jointly with Interior's land management agencies (FWS, BLM, BIA, and NPS) to insure that results are readily incorporated into management decisions.

Interior and the US Department of Agriculture (USDA) share many resource management challenges and opportunities, and manage many acres of adjoining lands. Both Departments seek to collaborate on inventorying and monitoring carbon stocks, supporting routine annual updates, developing policies for carbon management on both Departments' lands, and developing mutually reinforcing carbon management and landscape resilience approaches with managers of non-Federal lands. In 2016, working with USDA, the USGS will integrate USDA's expertise in the economic drivers of land conversion and short-term predictions for agricultural and forest lands, with USGS expertise in long-term land and climate change, satellite-based assessment of land characteristics, and non-market drivers of change. The collaboration would support the development of varied long-term management scenarios incorporating a range of policies and climate conditions. This would increase the capacity of both Departments' land management bureaus to assess the impacts of potential actions on carbon sequestration, and improve the characterization of uncertainties.

Adaptation and Resilience (+$6,818,000/+13 FTE)

Climate Adaptation and Resiliency - Vulnerability Assessment Database	(+$800,000/0 FTE)
Emerging Science Needs	(+2,268,000/+6 FTE)
Grand Challenge: Climate and Land Cover Change Effects	(+1,500,000/+3 FTE)
Interagency Coordination	(+2,250,000/+4 FTE)

Program Performance

Climate change requires the Nation to prepare for an increasingly wide range of temperature and precipitation patterns, including longer and more intense droughts, heat waves and other climate-related environmental change. Adaptation and resilience planning are key components to help our Nation and economy thrive in the face of climate challenges that could affect our infrastructure, food supply and physical safety. Examples of adaptation and resilience measures include using water resources more efficiently; adapting building codes to future climate conditions and extreme weather events; building flood defenses; and developing drought and other weather tolerant crops. In order for decisionmakers and industry to know where to focus their efforts, they must first know which climate change issues are most pressing.

In early 2013, Interior released a policy that requires Interior bureaus and offices to incorporate climate adaptation into policies, programs, planning, and operations. Identifying which species, ecosystems, and regions are likely to experience negative effects from climate change is a crucial initial step in building a climate adaptation program. Many Federal, State, tribal and other entities are conducting vulnerability assessments. These entities need to be able to easily access the findings of completed or ongoing assessments learn from existing methods and data to develop new studies, and combine results to provide larger and more meaningful conclusions. In 2016, the USGS would work with an existing interagency/State coordination group and tribes to continue development of a public cross-agency database and field guide to vulnerability assessments. This project would support Interior and other agencies in establishing standards and best practices, tracking progress for such assessments, and strategically prioritizing adaptive management actions.

Assuring that Federal, State, and other scientific activities are efficiently and effectively devoted to high-priority needs requires an increased level of coordination. The requested increase would allow the USGS to develop and implement the technical means to track relevant climate change adaptation-science across Federal agencies and ensure the availability of this information in a Web accessible format at the regional and national scale. Additionally, the USGS Climate Science Centers (CSCs) would continue to work with regional partners to identify common priorities and develop multiagency strategies that ensure coordinated implementation of public science investments to target the most critical management needs. This cross-agency dialogue convened by the CSCs represents a critical component of an effective and efficient Federal response to the climate science needs of managers. Investment in better coordination allows the USGS to better leverage the capacity and expertise of existing institutions, eliminate redundancy, make maximum use of existing data, and better support the needs of decisionmakers.

Another important step in climate adaptation and resiliency is ability to provide identification and documentation for long-term patterns of drought, storms, and other hydrologic events that affect coasts, urban areas, agriculture and other sectors of our Nation. Instrumental monitoring of climate variables such as temperature and precipitation spans only the last century or so; it is critical to integrate the data with fossil and chemical indicators of past climate to understand the magnitude, frequency, spatial impacts, and drivers of droughts and megadroughts (events that lasted decades). The requested increase would allow the USGS to expand a research effort begun in 2015 to document historical baseline levels of variability in water resources across the United States, providing context and setting expectations for modern-day patterns of droughts, storms, and other hydrologic events that affect coasts, urban areas, agriculture, and other sectors in our Nation. A high concentration of the U.S. population lives along the Nation's coastline; therefore, rising sea level poses significant impacts on society, infrastructure, and coastal habitats that serve as buffers from storm surges and severe weather events. An increasing science need is to improve the ability to accurately forecast rates and magnitudes of future sea level rise. The requested increase would allow the USGS to conduct research to develop consistent methods to measure the amount of water contained in alpine glaciers. This research would improve understanding of the potential contributions of melting glaciers and ice sheets to sea level.

Land use and land cover changes cause the boundaries between wet and dry regions to shift, altering regional climate patterns and vulnerability to droughts and floods. As regional resource managers plan future alterations or restorations of the landscape, those plans could be better supported by science that integrates long historical records of land change with modern Landsat satellite-based records of land change, and integrates these records into climate modeling efforts. Scientists and resource managers would benefit from a better representation of historical and modern-day water bodies, wetlands, and other hydrologic features in models. Important steps to provide this information have already started on the Florida peninsula, the proposed funding increase would allow the USGS to expand their efforts to include the Upper Colorado Basin. Likewise, water supply, demand, and drought are important issues in the Colorado River Basin, and the relative controls of climate variability verses human modification of the landscape on water availability are poorly known. Changes in fire frequency, arroyo cutting, and hydrology have been observed since the mid-19th century, and regional climate simulations that compare outcomes using pre-settlement and present-day land cover would clarify how such changes have influenced climate and the hydrologic system. The proposed increase would allow USGS researchers to develop pre-settlement and modern land cover datasets in a consistent format for input to regional climate sensitivity experiments. The datasets will be used in a regional climate model simulation to conduct paired pre-settlement and present-day simulations. Ultimately, researchers would work with resource managers to couple model outputs with hydrologic and ecological models to support proper management and planning needs.

Community Resilience and Partnerships +$16,500,000/+2 FTE

Community Resilience Toolkit	(+$11,000,000/0 FTE)
Translational Science Grants	(+$3,000,000/+2 FTE)
Tribal Climate Science Partnerships	(+$2,500,000/0 FTE)

Overview

Communities across the Nation face growing environmental challenges from natural hazards such as drought, floods, storms, and wildfires. The Community Resilience Toolkit (Toolkit) will improve community resilience by providing tools that help Federal, State, local and tribal governments understand, respond to climate and related environmental changes, and adapt their planning to maximize economic sustainability to these changes. Data include foundational and real-time data such as rainfall and tools include flood inundation and storm surge modeling. The use of these data and tools would improve community resilience, economic sustainability, and reduce long-term economic and human impacts of extreme storm events and natural disasters.

Water resource management across sectors ranging from energy and manufacturing to agriculture and drinking water in the 21st century require access to open and accessible water data. Another tool in the Toolkit will be to integrate water data into the toolkit and help the USGS participate in a new multi-agency Open Water Data Initiative. The 2016 budget request would allow water data that is fragmented among multiple bureaus and not readily accessible, into a connected, national water data framework on a geospatial platform. The Open Water Data Initiative will leverage existing partnerships and infrastructure to allow for greater data accessibility and better tools solution development.

The USGS has requested an increase in 2016 for the Community Resilience Toolkit. The Toolkit creates a clearinghouse where Big Earth Data Initiative (BEDI) data and other information could be made available. In addition the USGS would develop Web services that will apply the Observations and Measurements Data Model, an International Standards Organization standard, on priority climate data which would contribute to the Climate Data Initiative. This effort would provide an application that makes it easier for scientists and others to access, integrate, and apply their information. Leveraging the National Geospatial Platform, this effort would increase the availability of USGS scientific data that is required to support more informed landscape level decisionmaking.

These data and tools are resources that governors, mayors, county executives, tribal leaders and citizens can use to inform decisions and demonstrate how to best protect their communities by investing in more resilient infrastructure, updating building codes, adjusting the way they manage natural resources, and planning for rapid recovery from extreme weather events. The Toolkit would be a national clearinghouse for these data and tools. This clearinghouse is also a place where, scientists and community leaders can share their lessons learned and best practices as they develop innovative solutions in their own back yards.

The Toolkit creates the clearinghouse where other 2016 USGS requests could be available, such as: Big Earth Data and Open Water Data Initiative.

Program Performance

By providing competitive grant and agreement awards through the Federal Geographic Data Committee to other agencies, State, local and tribal governments, and non-government organization partners, the USGS would support the work of all Toolkit partners to develop a number of datasets and tools to ensure the long term sustainability of the Toolkit. This would require the expansion of the current USGS application and data hosting cloud environment to ensure that adequate technical infrastructure is available to support growing Toolkit requirements. Additionally, the National Geospatial Platform team would lead the development, enhancement and maintenance of the Climate Explorer application, the key geospatial viewer application for a wide range of resiliency data which is currently available.

These efforts support the Secretarial priority for Building a Landscape-Level Understanding of Our Resources. Community resilience can affect the economy, jobs, the environment, public health and welfare, security, and quality of life. The Toolkit would provide a portal with decision support tools, shared applications, visualization, and geospatial data to support resource-management decisionmakers and others. Applications developed for a specific event or scenario would provide capabilities that are accessible, shared, and applied to other events or actions through a community best practices clearinghouse where all levels of government would be leveraged collectively to address a wide range of local- to national-level challenges.

Community Resilience Toolkit **(+$11,000,000/0 FTE)**

National Geospatial Program (+$11,000,000/0 FTE)

In 2016, the USGS would capitalize on recent work undertaken by the USGS FGDC and several Federal agencies (the Department of Homeland Security, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, and the U.S. Global Change Research Program) to establish the Toolkit. The FGDC would use its many stakeholders to leverage and expand existing efforts to create the clearinghouse.

One important function of the Toolkit would be to provide communities with expanded access to data, trends, and projections in environmental change at scales that are relevant to decisionmaking. Currently, several Federal agencies are producing downscaled climate model information and scenarios that can be used for various planning activities. Communities do not have access to internally consistent, geographically scalable scenarios of change (e.g., climate, population, land use) across the United States, along with guidance on what the uncertainties are that should be considered when using these scenarios. One of the obstacles to filling this void in local and regional scenario development is a sustainable location on the Internet, which is accessible and widely known by all of our partners. This vision of providing coherent scenarios for use at local scales is consistent with the goal of the U.S. Global Change Research Program to provide “Actionable Science” to support climate change adaptation. Scenario development will be coordinated closely with the U.S. Global Change Research Program National Coordination Office with the aim of supporting a wide range of national, regional, State and local climate assessments and adaptation planning.

Another important function of the geospatial platform is the sharing of climate adaptation strategies and adaptation results in a setting that fosters the development of "communities of practice." Currently, there does not exist a U.S. government platform that facilitates the exchange of climate adaptation information among and across the Nation's local communities, or one that links communities with results from relevant private efforts such as the 100 Resilient Cities (100RC) project, which is working to build urban resilience in 100 member cities around the world. A Community of Practice Exchange will be initiated in the Toolkit in 2016 with the express purpose of helping communities identify best practices for adaptation planning, implementation, and evaluation. A rigorous and comparative analysis of the effectiveness of iterative risk management, adaptation strategies and decision support tools will be conducted and include consideration of stakeholder needs, institutional structures including multi-agency programs, cost/benefit analyses, model validation and traditional knowledge. Partnerships, including grants and other forms of support, will be offered to other governments, NGOs and other institutions that have already made substantial progress in some sectors and regions.

To assist and support community resiliency activities, the National Spatial Data Infrastructure (NSDI) Cooperative Agreements Program will be used to provide resources and support to competitively selected proposals. The program will be open to State, local and tribal governments, academia, and non-profit organizations. The projects will support community collaborations, application and tool development and data management efforts.

The requested increase would enable the USGS to extend the cloud computing technical infrastructure for the Toolkit to support the large data storage, data publication, and application hosting. This includes the data and models needed to support long-term scenarios for environmental management, economic development; and public health, welfare, safety and security. Additionally, the USGS would manage and maintain the Climate Explorer application and other centrally hosted and managed components of the Toolkit.

By the end of 2016, communities across the Nation will have access to a wide ranging and rapidly growing collection of data, tools, best practices and lessons learned that will help them make better decisions and build more resilient infrastructure as they plan for the future. By bringing together a comprehensive, national clearinghouse of key data, tools and expertise, and by enabling partners in other levels of government and the NGO community with grant funds and advanced technology tools, the Toolkit would help communities assess and understand their vulnerabilities and determine how to best take action.

Initial Plan for the Community Resilience Toolkit – The initial plan to develop and implement the Toolkit consists of three components: Community Development, Partnerships, and Infrastructure.

Community Development

In 2016, the USGS would use the requested increase to issue Grant proposals to enable the development of "communities of practice" as a part of the Toolkit in 2016. The requested increase would be applied to these grants/cooperative agreements to establish and support communities. The USGS would begin developing the Toolkit's core community components built in a way that could be used by all Toolkit partners. The requested increase would be used for outreach efforts, community assistance, and communication efforts to ensure community development and grant proposals are diverse and wide ranging.

Partnerships

The initiative would include a diverse number of partnerships to ensure the ongoing and permanent success of the Toolkit. The initiative would establish Public/Private partnerships to enable development of tools and support for community resiliency, such as, the publication of climate adaptation information and critical data and applications on adaptation scenarios at the local and regional levels. The requested increase would be used to support the development and publication of high-resolution regional climate scenarios and to support the further development of the Climate Explorer tool in collaboration with our partners at NOAA.

Infrastructure

The requested increase would enable the USGS to extend the cloud computing technical infrastructure for the Toolkit to support the large data storage, data publication, and application hosting. This includes the data and models needed to support long-term scenarios for environmental management, economic development; and public health, welfare, safety and security. The requested increase would be used to support a commercial cloud-computing infrastructure and would be used to provide technical support services for Toolkit partners.

Translational Science Grants **(+$3,000,000/+2 FTE)**

National Climate Change and Wildlife Science Center/
DOI Climate Science Centers (CSCs) (+$3,000,000/+2 FTE)

Ensuring that scientific understanding translates into practical application-ready solutions is a major challenge for the scientific community. The NCCWSC and the CSCs are implementing multiple approaches to ensure that managers and scientists "co-develop" actionable scientific products. In 2016, all CSCs would significantly expand their activities that support adaptation planning, with a focus on meeting the needs of specific decisions and planning activities, and on delivering application-ready scientific information. Building on existing CSC stakeholder interactions, the CSCs would work with

regional managers to identify high priority policy management decisions that could be informed by research results, then ensure close working relationships between scientists, managers and decisionmakers to assure that science projects provide decision ready outcomes. This ongoing collaboration between research scientists and land managers is essential to the successful production of actionable science. The NCCWSC would work with the USGS biological carbon sequestration project to identify options for building climate mitigation into climate adaptation planning, in particular by developing decision tools to help natural resource managers account for the carbon impacts of routine management practices as well as future climate adaptations. The CSCs would pilot this effort through regional projects focused on migratory birds and on the impacts of extended drought on ecosystems.

Tribal Climate Science Partnerships **(+$2,500,000/0 FTE)**

National Climate Change and Wildlife Science Center/
DOI Climate Science Centers (CSCs) (+$2,500,000/0 FTE)

Native American communities are increasingly engaging with the USGS and other partners to develop climate adaptation programs, and their needs for scientific and planning information are likewise increasing. In 2013, the NCCWSC/CSC Program established a Federal Advisory Committee: the Advisory Committee on Climate Change and Natural Resource Science (ACCCNRS). In early 2014, the ACCCNRS recommended that the USGS convene tribal and indigenous partners from across the CSC network to identify common and high priority tribal needs and are highlighted in an ACCCNRS report expected in April 2015. This recommendation would complement work at each of the CSCs, where scientists work with tribes to identify high priority tribal resource management concerns and build a science portfolio that provides information directly responsive to these needs. In 2016, the NCCWSC and the CSCs would help identify and implement best practices for the integration of traditional ecological knowledge into CSC science products. These efforts would be guided and supported by participation of tribal interests on CSC stakeholder committees and on the ACCCNRS as well as be coordinated with the Bureau of Indian Affairs (BIA) climate programs, tribal governments, consortia, and organizations, and other Federal climate efforts in Indian Country. Each CSC includes Native American representation on their stakeholder committees, and is developing trusted relationships with tribes in their region to identify high priority needs, and fund activities to meet those needs. The implementation of the BIA program to locate tribal climate science liaisons in five CSCs will provide additional capacity to both identify needs and communicate results to tribal users. Finally, in 2016, the CSCs would build on existing training and educational efforts, working with tribes in the development of climate adaptation strategies. The CSCs would expand research on key climate concerns, such as identifying those “First Foods” and similar culturally valued interests (plants, animals) whose existence or access is threatened by climate change.

Energy and Minerals

Energy and Minerals ($ in Thousands)	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
All-of-the-Above Energy	**8,549**	**30**	C-68
Unconventional Oil and Gas Research	**5,301**	**16**	C-69
Fisheries Program	1,200	4	C-71
Energy Resources	1,550	4	C-69
Contaminant Biology	1,400	5	C-70
Toxic Substance Hydrology	250	1	C-70
National Water Quality Program	901	2	C-69
Renewable Energy	**1,425**	**5**	C-71
Wildlife Program	150	1	C-71
Energy Resources	1,075	3	C-72
Volcano Hazards	200	1	C-72
Environmental Impacts of Uranium Mining	**2,023**	**9**	C-73
Contaminant Biology	273	1	C-73
Toxic Substance Hydrology	1,750	8	C-74
Redirection - ERP Publications	**-200**	**0**	C-74
Energy Resources	-200	0	C-74
Critical Minerals	**999**	**14**	C-75
Critical Minerals for the Nation's Economic Vitality	**440**	**14**	C-75
Mineral Resources	440	14	C-75
R&D to Address Environmental Impacts of Minerals Development	**559**	**0**	C-76
Mineral Resources	559	0	C-76
Grand Total	**9,548**	**44**	

Justification of 2016 Program Changes (+$9,548,000/+44 FTE)

All-of-the-Above Energy (+$8,549,000/+30 FTE)
Critical Minerals (+$999,000/+14 FTE)

Overview

Energy and mineral development affect the economy, national security, and standard of living of the Nation. The USGS provides science to inform decisionmakers as they balance adequate and reliable energy and mineral supplies with the potential impacts of their development and use. In 2016, the USGS is requesting an additional $9.5 million to continue and expand science efforts on environmental effects of unconventional oil and gas development; renewable energy development such as wind, solar, and geothermal; environmental impacts of uranium mining; a life-cycle analysis of critical minerals; and impacts of minerals development on the environment.

Program Performance

All-of-the-Above Energy (+$8,549,000)/+30 FTE)

Unconventional Oil and Gas Research	(+$5,301,000/+16 FTE)
Renewable Energy	+$1,425,000/+5 FTE
Environmental Impacts of Uranium Mining	(+$2,023,000/+9 FTE)
Redirection – ERP Publications	(-$200,000/0 FTE)

Overview

To improve understanding and addressing potential environmental, human health, and safety impacts of hydraulic fracturing and associated operational activities, the Department of the Interior (Interior), the Department of Energy (DOE), and the Environmental Protection Agency (EPA) are building on the core capabilities of each agency in synergistic ways that lead to complementary work, and conduct research that supports sound management and policy decisions by Federal, State, tribal, and local entities. In 2014, the three agencies released the *Federal Multiagency Collaboration on UOG Research Strategy* (*http://unconventional.energy.gov/pdf/Multiagency_UOG_Research_Strateg.pdf*). The Research Strategy addresses the highest priority research questions, incorporates new and innovative technological opportunities, and addresses community concerns associated with safely and prudently developing resources through hydraulic fracturing. The research strategy consists of the following topics: understanding the scale and nature of U.S. Unconventional Oil and Gas (UOG) resources; water quality; water availability; air quality and greenhouse gas emissions; effects on human health; ecological effects; and induced seismicity. In addition, the Research Strategy identifies a set of six multidisciplinary, collaborative "Flagship Projects" to provide examples of potential research and deliverables for the multiagency collaboration outlined in the Memorandum of Agreement. Interior, the DOE, and the EPA are conducting research that supports sound management and policy decisions by Federal, State, tribal, and local entities. The goal is to produce decision-ready information to ensure the prudent development of energy resources and the protection of human health and the environment.

While there are economic benefits associated with oil and gas production and industry has developed best management practices for well site activities, concerns remain about potential environmental, health, and safety impacts of hydraulic fracturing. A comprehensive understanding of these potential impacts will require a significant research effort, including baseline data collection across various geologic settings. Potential effects of hydraulic fracturing may include: (1) impacts to water resources, including the contamination of aquifers and surface waters from drilling and hydraulic fracturing chemicals, the cross-contamination of aquifers through faulty well construction and casing installation, the release of methane and other greenhouse gases into aquifers and the atmosphere, contamination from radioactive elements and other toxic chemicals in waters recovered during gas production, and the reduced availability of water, particularly in water-scarce areas; (2) landscape changes including soil erosion and habitat fragmentation; (3) generation of airborne pollutants; and (4) unintended seismic events from the subsurface injection disposal of recovered hydraulic fracturing and rock formation fluids. Singly or in combination, these potential effects might result in harmful impacts on human health or on terrestrial and aquatic wildlife and ecosystems.

The requested increase supports a continuation of ongoing research and monitoring activities, and continued work on the multidisciplinary, collaborative flagship projects on UOG resources identified in the *Federal Multiagency Collaboration on UOG Research Strategy*.

Program Performance

Unconventional Oil and Gas Research **(+$5,301,000/+16 FTE)**

Understanding the Scale and Nature of the U.S. Unconventional Oil and Gas Resources **(+$1,550,000 /+4 FTE)**

Energy Resources Program (+1,550,000/+4 FTE)

In 2016, the USGS would work to emphasize products that contain decision-ready information about the national unconventional oil and gas endowment. In 2016, the USGS would start a new effort to compare the characteristics and impacts of gas development and production using hydraulic fracturing in the Marcellus Shale both in Pennsylvania (where hydraulic fracturing is permitted) and in New York (where hydraulic fracturing is currently prohibited). There are areas of the Marcellus Shale natural gas trend in Pennsylvania and New York that are similar geologically and ecologically but are quite distinct regarding Marcellus gas production. For this new study, the USGS would study the geologic causes of variability in the Marcellus Shale in Pennsylvania and New York as related to the recovery of petroleum and water. This research would be tied to an investigation of baseline water quality and produced water disposal practices on the two sides of the border as part of a broader life cycle analysis.

Water Quality **(+$926,000 /+3 FTE)**

National Water Quality Program (+$676,000/+2 FTE)

The USGS would continue its efforts in 2016 to examine UOG impacts on groundwater and surface water quality. Understanding and managing risks from UOG development on water resources is one of the flagship projects identified in the Research Strategy. This project includes the development of analytical methods to detect a range of chemical additives (i.e., surfactants, corrosion inhibitors, biocides) commonly used in hydraulic fracturing fluid mixtures. This research is needed to understand potential impacts over the entire cycle of UOG operations, and develop best practices and mitigation technologies. The National Water Quality Program would also develop geochemical methods and models to evaluate contamination of water supplies. This includes examining possible inorganic elemental or isotopic fingerprints that could be used to identify UOG wastes as a source of contamination to environmental receptors. A focus would also be to identify the sources of the high selenium concentrations that have unexpectedly appeared in groundwater at several locations and conduct research on the use of stable carbon isotopes as a marker for injected fluids, such as fracturing fluid, into groundwater and surface water systems.

Toxic Substance Hydrology Program (+$250,000/+1 FTE)

In 2014, the Toxic Substance Hydrology Program collected environmental samples of water and sediment associated with a potential environmental release of UOG wastewater from a holding pond at an underground injection site in West Virginia. These samples are currently being analyzed by a battery of tests including naturally occurring inorganic and organic compound analyses, synthetic organic compound analyses, bioassays, and microbial analyses. These tests will determine if the wastewaters and associated contaminants can be detected in the environment. In 2015, the Toxic Substances Hydrology Program would continue this work and with additional funding in 2016, the USGS would continue its efforts to examine UOG impacts on water quality. Understanding and managing risks from UOG development on water resources is one of the flagship projects identified in the National Research Strategy. This project includes the development of analytical methods to detect a range of chemical additives (i.e., surfactants, corrosion inhibitors, biocides) commonly used in hydraulic fracturing fluid mixtures. This research is needed to help understand potential impacts over the entire cycle of UOG operations, and develop best practices and mitigation technologies. The USGS would continue to investigate the role of bacteria in natural attenuation of organic compounds in wastewaters from hydraulic fracturing flowback and produced waters.

Water Availability **(+$225,000/0 FTE)**

National Water Quality Program (+$225,000/0 FTE)

The USGS would continue to assess water quantity impacts of the development of unconventional petroleum resources and study how to identify alternate sources of water to replace the use of scarce fresh water. This work would be focused in the Williston Basin, where water resources are scarce and UOG development is proceeding at a rapid pace. Objectives of the multi-year effort, beginning in 2015 are (1) obtain and analyze water use data for related to unconventional oil and gas development in the Williston Basin from 2005-2015, (2) estimate consumptive use, (3) assist stakeholders in projecting water use requirements and availability associated with future UOG development, and (4) assess environmental risk (e.g., low-order stream vulnerability and prairie pothole risk assessment) attributed to UOG operations and water use.

Effects on Human Health **(+$1,400,000/+5 FTE)**

Contaminant Biology (+$1,400,000/+5 FTE)

The Contaminants Biology Program is requesting new funding in 2016 to assess the health and ecological impacts of unconventional oil and gas. In 2016, the Contaminants Biology Program would expand research on potential environmental exposure to organic and inorganic contaminants associated with UOG activity, to include the biological effects of that exposure to living organisms. The Contaminant Biology Program would focus on sites of highest priority to optimize field activity, sampling, and biological effects studies. This effort would add to the scientific knowledge needed to assess the toxicology and biological contributions of UOG development to potential health risks for living systems, which include humans.

Ecological Effects **(+$1,200,000/+4 FTE)**

Fisheries Program (+$1,200,000/+4 FTE)

The Fisheries program would continue to build upon the 2015 enacted investment into assessing potential ecological impacts associated with UOG development with an additional request for funding in 2016. wastewater toxicity testing will characterize and build upon the available ecological toxicity data for the chemicals in wastewaters that we project pose the greatest potential risk to terrestrial and aquatic ecosystems and species of concern. This includes testing for water contamination from salts, Naturally Occurring Radioactive Materials (NORMs), and toxic chemicals that are specifically used for hydraulic fracturing. Another project that the Fisheries program would continue to build upon is conducting landscape scale vulnerability assessments. Assessments will identify and prioritize key geographic regions, terrestrial and aquatic ecosystems and their services, sensitive aquatic communities, and critical wildlife habitats that have the greatest potential for impact from ongoing and potential UOG activities. This includes assessing impacts to aquatic life from large water withdrawals especially in headwater streams, and significant land disturbance from higher than average density of feeder pipelines from well pads to collector pipelines.

Renewable Energy **+$1,425,000/+5 FTE**

Wind and Solar **(+$150,000/+1 FTE)**
Wildlife Program (+$150,000/+1 FTE)
Geothermal **(+$400,000 /+3 FTE)**
Energy Resources Program (+$200,000/+2 FTE)
Volcano Hazards (+$200,000/+1 FTE)
Alternative Energy Permitting on Federal Lands **(+$875,000/+1 FTE)**
Energy Resources Program (+$875,000/+1 FTE)

Renewable Energy – Wind and Solar **(+$150,000/+1 FTE)**

Wildlife Program (+$150,000/+1 FTE)

Research on the causes and impacts of wildlife mortality from wind turbines and development of criteria for siting new facilities is well underway. However, little is known about the impacts of solar development on wildlife. Along with the need for increased understanding of potential impacts from solar, is the need for research on how to reduce impacts from commercial wind and solar energy development. Public and private managers are seeking efficient and effective ways to reduce wildlife interactions with solar and wind operations and to mitigate for possible impacts. Using technologies developed to enable the study of interactions of bats and birds with wind turbines, the USGS will expand investigations at solar facilities and explore options for innovative methods to reduce or offset negative interactions between wildlife and wind and solar operations. Preliminary studies showed that ultrasonic sounds and altering turbine operations had the potential to reduce the number of bird and bat fatalities. New research will be focused on developing these technologies and management strategies to reduce the chances that birds and bats will interact with energy facilities, such as a wind turbine, and reduce

associated fatalities that come with these interactions. This research will directly support the goals of State and Federal agencies, tribes, and energy managers to develop curtailment and mitigation strategies at wind and solar facilities.

Renewable Energy – Geothermal **(+$400,000/+3 FTE)**

Energy Resources Program (+$200,000/+2 FTE)

The Nation's transition to renewable fuels is challenged to provide "base power" that is steady, uninterrupted power, like coal and natural gas. Geothermal resources are a renewable energy source that can fill that base power role, but are highly underutilized in this country. The Energy Independence and Security Act (EISA) of 2007 directed the USGS to complete a comprehensive nationwide geothermal resource assessment that examines the full range of geothermal resources of the United States. The 2008 USGS geothermal resource assessment estimated the resource potential in identified and undiscovered geothermal systems, and documented that enhanced geothermal systems (EGS), a form of unconventional geothermal energy, could increase substantially the amount of geothermal resources. There is substantial potential for unconventional geothermal resources (EGS) on Federal lands, but these resources have not been thoroughly evaluated. New research and assessment work is critical to understanding these geothermal systems and determining the extent to which unconventional geothermal resources can play in the domestic energy mix. With the requested increase, the USGS would evaluate the geology and subsurface characteristics, and build on a very successful recent field test, to identify likely areas of potential exploration and development of unconventional geothermal resources. The USGS would improve research efficiency and improve decision-relevant products by investigating potential hazard and vulnerability at the same time as resource evaluations. This information is needed to support the periodic updates of a comprehensive national geothermal resource assessment as called for in EISA 2007.

Volcano Hazards (+$200,000/+1 FTE)

This effort proposes to build on Volcano Hazard Program assessment and monitoring capabilities to focus on high-priority geothermal targets including Akutan Island in Alaska and the Salton Sea Geothermal Field in California. Both targets could potentially generate power from geothermal resources for nearby residents and businesses, reducing reliance on other sources of energy. In Alaska, seismic monitoring equipment would be deployed that would help assess the size and extent of the subsurface geothermal system and estimate the size and stability of the geothermal system's production capability. At the Salton Sea, efforts will focus on modeling to assist in geothermal exploration and forecasting resource longevity.

Alternative Energy Permitting on Federal Lands **(+$875,000/+1 FTE)**

Energy Resources Program (+$875,000/+1 FTE)

The requested increase provides science to the agencies responsible for energy resource management on Federal Lands in several ways. Since the majority of geothermal resources are on public lands in the Western United States, the USGS works closely with the Bureau of Land Management (BLM) and others. The increase would allow a focused effort in targeted areas to survey and subsequently track the impacts

of geothermal development over time, which have been poorly characterized to date. This effort would focus on key areas where there are, or may be, issues related to ongoing geothermal production. The increase would also allow for additional support for researching induced seismicity related to geothermal development on Federal lands, and help to determine the risks and potential mitigation plans should development be proposed. The BLM and other bureaus could use information from this proposed increase for land use planning and potentially a targeted environmental impact statement for high potential use areas. In addition, outcomes from this research would support science and information needs identified by BLM, Fish and Wildlife Service, and others in the draft Desert Renewable Energy Conservation Plan (DRECP), which is a "landscape-scale plan that uses science to inform the siting of renewable energy development projects and the conservation of species, creating systematic habitat protection and connectivity improvements across the Mojave and Colorado/Sonoran desert regions" (DRECP Executive Summary, September 2014). Additional users of this information include geothermal power companies, which can use probabilistic hazard and risk data to lower vulnerability of potential power development assets and design better monitoring to protect those assets. With the additional funding, the USGS will be able to accelerate work at an existing research site or begin work at a new site.

Environmental Impacts of Uranium Mining **(+$2,023,000/+9 FTE)**

Contaminant Biology (+$273,000/+1 FTE)
Toxic Substances Hydrology (+$1,750,000/+8 FTE)

Overview

In January 2012, the Secretary of the Interior withdrew over one million acres of public lands in the Grand Canyon region from mining for 20 years under the Mining Law of 1872. However, even under the withdrawal, some mining will occur on valid existing claims. For example, the Canyon Mine (on U.S. Forest Service [USFS] lands south of the Grand Canyon) and the EZ Mine (on Bureau of Land Management [BLM] property north of the Grand Canyon) are expected to begin ore extraction in the near future. A key factor in the Secretary's decision was a lack of scientific information. The USGS developed a 15-year science plan in collaboration with the BLM, National Park Service, U.S. Fish and Wildlife Service, and the USFS. The studies would provide critical information for future decisions on withdrawal of lands and help inform the development, mitigation, reclamation, and ecological restoration of mines on valid existing claims, as applicable.

Northern Arizona Uranium Mining Contamination Research **(+$2,023,000/+9 FTE)**

Contaminant Biology (+$273,000/+1 FTE)

The proposed increase would support characterization of radiation and chemical concentrations in sentinel species (e.g., birds, mammals, and reptiles) from samples obtained at targeted active mine sites. Biological surveys and samples (water, dust, and biota) were collected at the Pinenut and Arizona 1 Uranium Mines, Arizona Strip in 2015. These results will complement the characterization of radiation and chemical concentrations in biota from a pre-mined ore body that was completed in 2015. These foundational activities are necessary for measuring the environmental effects of mining uranium, and its

associated release of radiation, beyond what is naturally occurring in this area of the country to determine whether those increases pose a risk to biota. In 2016, the USGS would analyze the levels or uranium in dust, water, and biota at active mine sites, and begin modeling the "natural" transport and occurrence of uranium and radiation in native animals and plants. Biological samples will also be collected at springs near reclaimed mine sites to determine if residual contamination is cause for concern for humans and wildlife. Results will be used to develop a modeling tool to assess ecosystem health before, during, and eventually after uranium extraction. The knowledge gained from these studies will be used for developing prevention and mitigation strategies to ensure that the health and sustainability of natural resources are balanced with economic development. This study will provide science needed by the Secretary of the Interior for making sound decisions regarding extraction activities on Federal lands.

Toxic Substances Hydrology (+$1,750,000/+8 FTE)

The requested increase continues the implementation of the integrated 15-year science plan by collecting new baseline data, expanding smaller scale studies begun in previous years, and laying the foundation for future modeling and monitoring efforts. The increase would also be used to begin new work on the potential for persistent contaminant threats from abandoned and legacy mining activities. Work initiated in 2015 would continue in 2016 to characterize the baseline conditions of soil, groundwater, and surface water at the Canyon and EZ Mine sites before ore extraction begins. This would be done in cooperation with agency partners and private mining companies, and would complement USGS work on Trust resources (animal and plant species) started at Canyon Mine in 2013 and 2014. This baseline work is crucial for comparison after extraction occurs and enables understanding of the extent of naturally occurring versus mine- related uranium and associated contaminants in soil, water, and biota.

In addition, work would begin to determine potential pathways of uranium exposure, such as movement through groundwater-flow paths, surface water, and wind dispersion as well as the potential for biological uptake from legacy as well as new mining activities. This includes continued and expanded monitoring of water quality and uranium levels in the Colorado River in the Grand Canyon, Kanab and Havasu Creeks, and other regional rivers, streams, intermittent washes, and springs. USGS researchers would analyze data continually to describe spatial and temporal patterns of uranium in soil and water samples, and include information to develop regional exposure models that would shape subsequent research and monitoring components.

Redirection – ERP Publications **(-$200,000/0 FTE)**

Energy Resources Program (-$200,000/0 FTE)

This redirection would allow for many of the ERP's publications to be published in a digital format in outside journals, allowing funds to be redirected towards other priorities in the Energy Resources Program.

Critical Minerals +$999,000/+14 FTE

Critical Minerals for the Nation's Economic Vitality	(+$440,000/+14 FTE)
R&D to Address Environmental Impacts of Minerals Development	(+$559,000/0 FTE)

Program Performance

Critical Minerals for the Nation's Economic Vitality (+$440,000/+14 FTE)

Mineral Resources Program – Critical Minerals	(+$2,440,000/+14 FTE)
Mineral Resources Program - Sun Setting Activities	(-$2,000,000/0 FTE)

The 2016 request for the Mineral Resources Program will be used to continue life-cycle analysis for critical minerals such as rare earth elements. A life-cycle analysis will trace the flow of these critical minerals from generation and occurrence through interaction with society and the environment to ultimate disposition and disposal. The Nation faces key economic decisions within each stage of the resource life cycle. Scientific understanding is an essential input to these decisions. The program change will support new workforce capability to address the main thrusts of the President's four Office of Science and Technology Policy (OSTP) Working Groups currently focused on critical and strategic materials essential to national security, economic vitality, and environmental protection. By expanding work on Materials Flow analysis, the initiative will also accomplish needed modernization of the National Minerals Information Center part of the Mineral Resources Program. Redirection of sun-setting activities in the Mineral Resources Program will support Administration priorities in the areas of Critical Minerals and Research and Development to Address the Environmental Impacts of Minerals Resource Development.

In addition to national security and economic vitality, critical minerals research is important to the President's focus on protecting the environment. Critical minerals research fosters better understanding of the environmental consequences of mining, such as the impacts of metal mixtures in mineralized drainage, mineral levels in the built and waste stream environments, geochemical composition of soil, and the impacts of mining on human health. For instance, the Mineral Resources Program's development of an interactive Web tool called the U.S. Soil Map has helped further the understanding of the geochemical makeup of soil at thousands of sites all over the Nation. This and additional data that will become available from the extension of critical minerals research will be used to better understand whether elements in soil are naturally occurring or externally introduced. These data can be used to extrapolate potential health effects arising from areas that contain a higher-than-normal concentration of a particular element. Furthermore, critical minerals research provides information essential to the development of renewable energy resources. Knowledge of the elements needed for the production of wind turbines and solar panels, as well as the quantities and locations of those elements, can support the proliferation of clean energy solutions for the Nation.

R&D to Address Environmental Impacts of Minerals Development **(+$559,000/0 FTE)**

Mineral Resources Program (+$559,000/0 FTE)

The 2016 request will allow for the focus of efforts on development of new science and tools to reduce the impacts of minerals extraction, production, and recycling on the global environment and human health, including research on supply chain, life cycle, resource sustainability, and minimizing environmental impacts of mineral extraction. This additional funding will allow for enhanced work on: toxicity of multiple metals associated with platinum group deposits; trace metal mobility in the Yellow Pine mining district, Idaho; groundwater quality in uranium mining; geoenvironmental health models of mineral deposits; geoenvironmental signatures of rare earth element deposits in Alaska; and refinement of national geoenvironmental models. Other environmental activities include efforts to better understand emerging environmental geochemical challenges for future mining, and the uses, characteristics, and environmental health implications of metal and mineral commodities in the built environment.

Science Infrastructure

Science Infrastructure ($ in Thousands)	2016 President's Budget Program Changes	2016 President's Budget Program Changes - FTE	Page #
Infrastructure Capacity to Support the Science Mission	**18,931**	**16**	C-78
Enhancing Science Support Capability to Support Science Mission Goals	**2,617**	**16**	C-78
Administration and Management	1,997	14	C-78
Information Services	620	2	C-78
Operations and Maintenance Stewardship	**2,712**	**0**	C-80
Rental Payments and Operations & Maintenance	2,712	0	C-80
Reducing the Facilities Footprint - Cost Savings and Innovation Plan (CSIP)	**11,602**	**0**	C-80
Rental Payments and Operations & Maintenance	11,602	0	C-80
Sustainability Investments	**2,000**	**0**	C-81
Rental Payments and Operations & Maintenance	2,000	0	C-81
Science Coordination	**500**	**1**	C-82
Tribal Science Coordination	**300**	**0**	C-82
Administration and Management	300	0	C-82
DOI Science Coordination	**200**	**1**	C-82
Administration and Management	200	1	C-82
Engaging the Next Generation: Building a 21st Centrury Workforce	**1,700**	**2**	C-83
Mendenhall Program Postdocs	**500**	**1**	C-83
Administration and Management	500	1	C-83
Youth in Underserved Communities	**200**	**0**	C-84
Administration and Management	200	0	C-84
Youth & Education in Science	**1,000**	**1**	C-84
Administration and Management	1,000	1	C-84
Grand Total	**21,131**	**19**	

Justification of 2016 Program Changes (+$21,131,000/+19 FTE)

Infrastructure Capacity to Support the Science Mission	(+$18,931,000/+16 FTE)
Science Coordination	(+$500,000/+1 FTE)
Engaging the Next Generation: Building a 21st Century Workforce	(+$1,700,000/+2 FTE)

Overview

Science Infrastructure includes the essential support functions and services and facilities which form the foundation for the USGS science mission. Achieving high-quality science research depends on having the required resources, including scientific equipment and supplies, facilities and laboratories; scientists, technicians and researchers; partnership agreements and contracts in place when needed, and the management processes to control and best utilize these resources. In 2016, the USGS is requesting an increase of $21,131,000 million for these critical activities. Included in the increase is funding to enhance science coordination, expand youth and education opportunities, implement cost savings and sustainability efforts, and support essential management, finance, acquisition, safety, and information technology services. The request for science infrastructure is commensurate with the increase request for science funding, and will strengthen core capabilities and science support activities.

It is comprised of:

- Administration and Management (A&M)
- Information Services
- Facilities

Infrastructure Capacity to Support the Science Mission

(+$18,931,000/+16 FTE)

Enhancing Science Support Capability to Support Science Mission Goals	(+$2,617,000/+16 FTE)
Operations and Maintenance Stewardship	(+$2,712,000/0 FTE)
Reduce Facilities Footprint-Cost Savings and Innovation Plan (CSIP)	(+$11,602,000/0 FTE)
Sustainability Investments	(+$2,000,000/0 FTE)

Program Performance

Enhancing Science Support Capability to Support Science Mission Goals (+$2,617,000/+16 FTE)

Administration and Management	(+$1,997,000/+14 FTE)
Information Services	(+$620,000/+ 2 FTE)

The essential support functions and services provided by the Administration and Management (A&M) subactivity form the foundation for the USGS science mission. Achieving high-quality science research depends on having the required resources, including scientific equipment and supplies, facilities and laboratories; scientists, technicians and researchers; partnership agreements and contracts in place when needed, and the management processes to control and best utilize these resources. The breadth of responsibilities required include scientific integrity processes, purchasing scientific equipment and field supplies, developing science agreements with partners, contracting for support scientists and researchers, safety training, hazardous waste management, funds management, succession planning, hiring, staffing and employee development and training and property and facilities management. Each of these fulfills unique responsibilities with unique training and skillsets and the functions are not interchangeable. Growth of the science mission and changes to science projects generate additional requirements for these support functions. The ability to execute the science mission is jeopardized if A&M funding is not maintained commensurate with science funding. This program change would allow A&M to strengthen these core capabilities and science support activities. New science projects require appropriately trained and qualified people, equipment and supplies to conduct research and field work. This increase will ensure that science support has the capacity to support programmatic increases for science provided in 2016.

Strategic reviews and workforce analysis have guided the A&M subactivity in preserving core capabilities while adapting to changing requirements and technologies. A&M supported functions will continue to use workload and workforce analysis to adapt to meet evolving requirements, and ensure that science support funding is “right sized” to appropriately support the science mission of the USGS.

This increase would enhance the ability to continue these strides, and improve service delivery by supporting closer collaboration between service providers and scientists. Examples of the critical support provided may include:

- Additional acquisition support that would assist with developing new statements of work and accomplish procurement actions for the $137.2 million in proposed 2016 programmatic changes requiring procurements for new research capability for initiatives such as earthquake early warning, volcano ash-fall modeling and seismic monitoring of geothermal energy producing fields and modification of existing agreements affected by research projects which are reduced or eliminated.
- Additional human capital support to hire the 207 FTE increase for new initiatives such as pollinator studies, wildlife and fish population response to climate change in the Artic and Sage-land assessments, and new researchers for drought, and scientists redirected from lower priority science.
- Management analysts and funding to develop automated tracking systems, to establish customer service metrics and quality standards for administrative processes for executive leadership and senior management use in continuous evaluation of service and quality levels and balancing resources. For instance, ensuring that acquisition and human resources have the tools to better communicate with their customers about the status of their procurement and hiring actions, and streamline processes to ensure that the work is being done in a timely and reasonable manner.
- Bureau approving official would apply scientific integrity principals in support of the $137.2 million in additional science priorities for the USGS. New science projects focusing on areas such as pollinators, drought, and the Arctic produce new research results that would require the application of scientific integrity principals to evaluate methods and assure delivery of peer-reviewed science to publications. In addition, the implementation of Web-based journals, similar to the 24-hour news cycle, increases the pressure to compress the time it takes to deliver scientific study results. An increase to FTE in this area would decrease the amount of backlog and time it takes to move through the review process, delivering science products to land-use managers and the public quicker, without risking scientific quality.
- Technology transfer and agreements specialist would review new and modified non-standard agreements for statutory and regulatory compliance and assist scientists with the development of cooperative research and development agreements and technology transfer. Technology transfer enables the rapid commercial exploitation of federally funded research. For instance, USGS science recently led to an invention that has been submitted for a U.S. patent for antibacterial clay that can be used to treat skin infections resistant to antibiotics. Antibiotic resistant infections affect two million people each year and at least 23,000 die as a direct result of these infections. Rapid commercialization, for instance, will also make earthquake early warning technology more widely available.
- Internal controls specialists to evaluate increased risk associated with program changes and assist science management in developing risk reduction processes. This FTE would assist in developing adequate internal controls to ensure resources are efficiently managed and fulfill mission requirements for new cooperative agreements, which consist of field activities, data-

collection and equipment that produce models and recommendations for improving disaster response to coastal hazards and contracts for high-resolution data. Historically, programs undergoing significant change are susceptible to increased risk and audit visibility.

Investments in A&M support functions and processes allow scientists to focus on science by providing the tools, people and support needed to accomplish the mission.

The proposed increase to Information Services would provide more robust support for the bureau in the areas of information hosting and processing and information technology services. The Office of Enterprise Information (EI) will make high-value assets and technical tools available to the public in support of the administration's Open Government Initiatives. EI would use the funding to increase efficiency in USGS processes, such as programming and developing tools, to assist with IT spending and use of Universal Product Codes and reporting to DOI, and improving existing Web forms and tools that will benefit and impact a large body of employees within the USGS.

Operations and Maintenance Stewardship **(+$2,712,000/0 FTE)**

Rental Payments and Operations and Maintenance (+$2,712,000/0 FTE)

The requested increase will improve the performance of the USGS real property portfolio by providing the bureau the ability to complete annual operations and maintenance responsibilities and would ultimately have a positive impact on the science programs, decreasing the amount of science dollars needed to cover the existing facilities shortfall.

The increase will allow the USGS to approach proper funding levels in the Operations and Maintenance component of the Rental Payments and Operations and Maintenance subactivity for USGS owned facilities slowing the increasing deferred maintenance backlog. The increase will help the bureau realize the full life cycle of its real property assets and help prevent emergency repairs that result in unplanned additional repair costs and unexpected outages compromising the science missions of the USGS. In addition, the increase will enhance the ability to meet the requirements of statutory energy goals; increase efforts of energy reduction, water conservation, and waste reduction; and enhance the USGS's ability to meet specified environmental requirements, as well as enable more efficient and economical maintenance of its real property assets and enhance the bureaus ability to fund Cost Savings and Innovation Plan (CSIP) projects.

Reducing the Facilities Footprint-Cost Savings and Innovation Plan (CSIP) (+$11,602,000/0 FTE)

Rental Payments and Operations and Maintenance (+$11,602,000/0 FTE)

Because the USGS relies on the General Services Administration (GSA) owned and leased buildings for about 67 percent of the space it occupies, the USGS has no ability to reduce fixed rental rates at these sites and can only offset the higher facility costs by vacating space. Therefore, primary emphasis is placed on improving space utilization, consolidating operations within, and relinquishing space to GSA provided offices, laboratories, data centers, and warehouses.

The proposed increase would accomplish a mixture of Cost Savings and Innovation Plan (CSIP) projects and Deferred Maintenance (DM) projects. Since 2012, the USGS has been funding its CSIP projects from the Deferred Maintenance and Capital Improvements (DMCI) subactivity. The proposed increase in funding would allow the USGS to restore the $2.22 million in DMCI funding currently being used to fund CSIP projects, and give the USGS the ability to invest in additional CSIP projects that allow the USGS to consolidate space, reduce the occupancy footprint, improve utilization and create real property cost savings and other efficiencies. The requested increase for CSIP projects would allow the USGS to implement numerous projects that would further reduce the USGS footprint by approximately 138,000 Rentable Square Feet (RSF).

The CSIP has provided the USGS with the ability to reduce its footprint by more than 540,000 RSF from 2012 through 2014. By 2016, the USGS anticipates an additional reduction of 175,000 RSF, bringing the overall footprint reduction to 715,000 RSF. This would be a 12 percent decrease of the USGS space portfolio since 2012. These efforts focused on the USGS three major centers in Reston, VA, Denver, CO, and Menlo Park, CA. Each of these centers were successful in taking on major consolidation projects, reducing space requirements, actively seeking co-location opportunities and vacating more expensive space. The achieved results were the direct impact of the bureau's CSIP activity.

In 2016, the bureau will continue its progress toward accomplishing the savings targets set by Interior. The USGS will continue to fund the library consolidation projects at the Denver Federal Center and Menlo Park Campus, which will immediately reduce the space occupied by the library by 29,400 SF; a 48 percent reduction. Completing the Menlo Park library project will also speed up the overall consolidation plan at the Menlo Park Campus, which will ultimately release the remainder of Building 3; an additional reduction of 50,100 SF. The USGS will also continue to fund a co-location project with the Bureau of Reclamation, in Boulder City, NV. This project will significantly reduce the rent costs as well as lessen the Interior's overall footprint.

Sustainability Investments **(+$2,000,000/0 FTE)**

Rental Payments and Operations and Maintenance (+$2,000,000/0 FTE)

The USGS awarded an Energy Savings Performance Contract (ESPC) in July 2014 for $12 million. The ESPC will reduce the USGS's energy consumption by 15 percent, potable water use by five percent and Scope 1&2 Greenhouse Gas emissions by nine percent. The ESPC will annually generate over $650,000 of savings, which will pay for the energy and water improvements. On average these projects would pay for themselves in 16 years. During the ESPC award process, a series of preliminary audits were performed that identified an additional $13.0 million in Energy Conservation Measures (ECMs) not included the ESPC award. The ECMs include a wide range of improvements in boiler systems, chiller plants, building automation, HVAC, building envelope, and electric motors and drives. The ECMs would take place at the Earth Resources Observation and Science Center, Leetown Science Center, Patuxent Wildlife Research Center, Northern Appalachian Research Laboratory, Conte Anadromous Fish Laboratory, Northern Prairie Wildlife Research Center, Upper Midwest Environmental Sciences Center, and National Wetlands Research Center. Due to various reasons, these ECMs were evaluated for inclusion in the ESPC but ultimately were not included in the award. These additional ECMs are still

viable measures and the $2 million program change will allow the USGS to pursue these ECMs to further reduce the bureau's energy consumption and generate savings of approximately $100,000 to $150,000 annually.

Science Coordination (+$500,000 /+1 FTE)

Tribal Science Coordination (+$300,000/0 FTE)
DOI Science Coordination (+$200,000/+1 FTE)

Overview

Scientific research provides the basis for technological advancements such as earthquake early warning; limiting ecosystem destruction from invasive species such as Asian carp and developing complementary land-use management techniques for Federal lands such as energy exploitation and endangered species refuges. Collaborating with partners on science projects and goals expands science knowledge exponentially by sharing knowledge and data across organizations, developing complementary rather than duplicative projects, and integrating results to derive decision-quality data sooner than would be possible from isolated science projects.

Program Performance

Tribal Science Coordination (+$300,000/0 FTE)

Administration and Management (+$300,000/0 FTE)

Efforts to strengthen tribal partnerships in science are proposed for the USGS Office of Tribal Relations (OTR). The USGS would make existing partnerships more robust by enhancing and expanding outreach coordination efforts among Tribes and USGS regions. Working with the USGS Regional and Mission Area tribal liaisons, the increased support to the USGS OTR will increase the USGS ability to forge partnerships with intertribal organizations and to connect Tribes to USGS scientists and staff in other Interior bureaus and Federal agencies. The funding would also support expanding tribal training via the Technical training in Support of Native American Relations (TESNAR) program, which provides for the transfer of information from USGS to tribal members in the use of research techniques and technology for use in climate resilience and mitigation. This training provides capacity building to Tribes and supports self-determination in their climate resilience and mitigation activities.

DOI Science Coordination (+$200,000/+1 FTE)

Administration and Management (+$200,000/+1 FTE)

As the science bureau of the Department of the Interior, the USGS provides science to inform the land and resource management decisions of Interior. The increase supports strengthening the coordination of the science priorities of Interior bureaus to ensure the USGS is delivering decision ready science to meet Interior's highest priority needs. The science delivered must be of the highest quality and conducted with

the highest integrity. The increase also supports Interior's scientific integrity process. The USGS leads the scientific integrity process for all Interior bureaus. This unified approach strengthens scientific research and application across Interior and aids land management and land use policy development and implementation. The scientific integrity process ensures all research is conducted with integrity and is subject to rigorous review. The funding would support a dedicated scientist to coordinate USGS science efforts with other Interior bureaus and to support Interior's science integrity process.

Engaging the Next Generation: Building a 21st Century Workforce (+$1,700,000/+2 FTE)

Mendenhall Program Postdocs	(+$500,000/+1 FTE)
Youth in Underserved Communities	(+$200,000/0 FTE)
Youth and Education in Science	(+$1,000,000/+1 FTE)

Overview

Engaging the next generation in the USGS science and science support workforce is an investment in the future economic vitality of the Nation, which will contribute to maintaining the Nation's preeminence in science and technology. This benefits all United States citizens through economic advancement, mitigation of natural hazards, and stewardship of natural resources and public lands. As part of the Nation's effort to lead the world in science and technology, the USGS provides robust mentoring, training, and educational opportunities to young people to grow the science workforce in the 21st century. Engaging youth is a part of the USGS legacy. USGS internships provide initial work experiences and science literacy to young people on relevant, cutting-edge science issues and creates a ready source of future employees, contributing to a robust national scientific community.

Program Performance

Mendenhall Program Postdocs **(+$500,000/+1 FTE)**

Administration and Management	(+$500,000/+1 FTE)

The Mendenhall Research Fellowship Program is the flagship postdoctoral research program for the USGS. Established in 2001, this program has grown into one of the most prestigious and coveted postdoc programs in science. Through the Mendenhall Program, the USGS obtains the some of the best available new PhD talent to address the needs of its science mission. This funding will be used to recruit a specific number of Mendenhall Fellows to carry out research that covers the entire spectrum of USGS science. This increased funding will provide stability to the program and the opportunity for the establishment of a consistent high standard for projects and researchers.

Youth in Underserved Communities **(+$200,000/0 FTE)**

Administration and Management (+$200,000/0 FTE)

This increase would provide opportunities to grow outreach programs to youth in underserved communities, such as the Denver Mayor's Office/USGS partnership and the Native Youth in Science – Preserving our Homelands programs. Additional funding would help the USGS to provide an understanding of the opportunities available through science, technology, engineering and mathematics (STEM) studies and demonstrate a path toward development as future scientists, as illustrated in our work with GeoFORCE students. Increased funding would build upon and expand current hydrologic, biologic, and physical science technician programs with Gateway, Vermillion, SD, and Northern Virginia Community Colleges, and allow for program startup at new minority serving institutions and tribal colleges. Hydrologic Technicians constitute one of the top two career series within the USGS, with 25 percent vacancies estimated from retirements or other departures from the USGS in the next three to five years. The Hydrologic Technician Interest Committee, comprised of USGS leaders in Hydrology across the Nation, is dedicated to mentoring and succession planning efforts, with a focus on veterans, youth, and diversity.

Youth and Education in Science **(+$1,000,000/+1 FTE)**

Administration and Management (+$1,000,000/+1 FTE)

The requested increase would enable the USGS to sustain and build on existing youth hiring and youth outreach activities which contribute directly to STEM capabilities for the Nation and introduce future scientists to the value of public service in the Earth and biological sciences. The Office of Science Quality and Integrity combined the Youth and Education Offices to form the Youth and Education in Science Office in 2015. This office (1) facilitates a strong coordinated effort across the USGS to leverage resources and support the engagement, mentoring, and employment of youth; (2) develops youth and education strategic directions as they relate to the USGS science and workforce planning goals; (3) expands USGS education and internship programs for students underrepresented in STEM, tribal colleges, and to veterans; (4) develops and enhances current STEM programs that are pipelines to STEM careers (i.e., EdMAP); and (5) provides opportunities to expand partnerships in support of the 21st Century Conservation Service Corps. As part of this strategy, the Youth and Education in Science Council has been developed, which will help leverage youth engagement opportunities by partnering with USGS science centers, offices and stakeholders to achieve mission goals.

Budget at a Glance

Budget at a Glance (Dollars in Thousands)							
	2014 Actual	2015 Enacted	Fixed Costs	Seasonal Federal Health Benefit	Internal Transfers	Program Changes	2016 Budget Request
Appropriation: Surveys, Investigations, and Research **Ecosystems**							
Status and Trends	**20,473**	**20,473**	**241**	**254**	**0**	**1,210**	**22,178**
Fixed Costs	0	0	241	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	254	0	0	0
Pollinators	0	0	0	0	0	1,210	0
Fisheries Program	**20,886**	**20,886**	**285**	**301**	**0**	**3,950**	**25,422**
Fixed Costs	0	0	285	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	301	0	0	0
WaterSMART: Ecological Flows	0	0	0	0	0	2,500	0
Great Lakes Fisheries Assessments	0	0	0	0	0	250	0
Unconventional Oil and Gas Research	0	0	0	0	0	1,200	0
Wildlife Program	**44,757**	**45,257**	**615**	**649**	**0**	**150**	**46,671**
Fixed Costs	0	0	615	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	649	0	0	0
All-of-the-Above Energy: Renewable Energy - Wind & Solar	0	0	0	0	0	150	0
Environments Program	**36,244**	**36,224**	**360**	**380**	**2,191**	**3,600**	**42,755**
Fixed Costs	0	0	360	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	380	0	0	0
OCS Ecosystems Decisions	0	0	0	0	0	300	0
Critical Landscapes: Sagebrush Landscape	0	0	0	0	0	1,000	0
WaterSMART: Drought	0	0	0	0	0	300	0
Critical Landscapes: Arctic	0	0	0	0	0	700	0
Critical Landscapes: Columbia River	0	0	0	0	0	150	0
Ecosystem Services: National Ecosystems Framework	0	0	0	0	0	450	0
Critical Landscapes: Puget Sound	0	0	0	0	0	200	0
Natural Hazard Science for Disaster Response: Wildfire Response	0	0	0	0	0	500	0
Internal Transfer: Moved from National Water Quality	0	0	0	0	2,191	0	0
Invasive Species	**13,080**	**16,830**	**98**	**103**	**0**	**2,250**	**19,281**
Fixed Costs	0	0	98	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	103	0	0	0
Brown Tree Snakes	0	0	0	0	0	250	0
New and Emerging Invasives of National Concern	0	0	0	0	0	2,000	0
Cooperative Research Units	**17,371**	**17,371**	**302**	**319**	**0**	**2,000**	**19,992**
Fixed Costs	0	0	302	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	319	0	0	0
CRU Enhanced Support and Scientists for Tomorrow	0	0	0	0	0	2,000	0
Activity Total, Ecosystems	**152,811**	**157,041**	**1,901**	**2,006**	**2,191**	**13,160**	**176,299**

Budget at a Glance (Dollars in Thousands)							
	2014 Actual	2015 Enacted	Fixed Costs	Seasonal Federal Health Benefit	Internal Transfers	Program Changes	2016 Budget Request
Climate and Land Use Change							
Climate Variability							
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	**23,735**	**26,735**	**84**	**4**	**0**	**10,580**	**37,403**
Fixed Costs	0	0	84	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	4	0	0	0
Climate Adaptation and Resiliency - Vulnerability Assessment Database & Field Guide	0	0	0	0	0	800	0
Interagency Coordination	0	0	0	0	0	2,250	0
Translational Science Grants	0	0	0	0	0	3,000	0
Tribal Climate Science Partnerships	0	0	0	0	0	2,500	0
WaterSMART: Drought	0	0	0	0	0	1,030	0
Critical Landscapes: Arctic	0	0	0	0	0	500	0
Resilient Coastal Landscapes and Communities: Climate Outputs	0	0	0	0	0	500	0
Climate Research & Development	**20,495**	**21,495**	**257**	**11**	**0**	**4,893**	**26,656**
Fixed Costs	0	0	257	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	11	0	0	0
Emerging Science Needs	0	0	0	0	0	2,268	0
Grand Challenge: Climate & Land Cover Change Effects	0	0	0	0	0	1,500	0
WaterSMART: Drought	0	0	0	0	0	1,125	0
Carbon Sequestration	**9,359**	**9,359**	**52**	**2**	**0**	**9,100**	**18,513**
Fixed Costs	0	0	52	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	2	0	0	0
Grand Challenge: Carbon Inventory & Decision Support Tools	0	0	0	0	0	2,000	0
Biological Carbon Monitoring and Tools	0	0	0	0	0	6,500	0
Ecosystem Services: Biological Carbon Sequestration	0	0	0	0	0	400	0
Biological Carbon Sequestration: Land Management	0	0	0	0	0	200	0
Subtotal: Climate Variability	***53,589***	***57,589***	***393***	***17***	***0***	***24,573***	***82,572***
Land Use Change							
Land Remote Sensing	**67,894**	**67,894**	**323**	**14**	**0**	**29,300**	**97,531**
Fixed Costs	0	0	323	0	0	0	0
Healthcare for Seasonal Workers	0	0		14	0	0	0
Landsat Science Products for Climate and Natural Resources Assessments	0	0	0	0	0	4,000	0
WaterSMART: Remote Sensing	0	0	0	0	0	400	0
National Civil Applications Program	0	0	0	0	0	-1,000	0
WaterSMART: Drought	0	0	0	0	0	250	0
Critical Landscapes: Arctic	0	0	0	0	0	250	0
Big Earth Data: Data Cube	0	0	0	0	0	600	0
Landsat Ground Systems Development	0	0	0	0	0	24,300	0
Resilient Coastal Landscapes and Communities: Imagery Datasets and Analytical Tools for Coastal Analysis	0	0	0	0	0	500	0
Land Change Science	**10,492**	**10,492**	**128**	**5**	**0**	**1,100**	**11,725**
Fixed Costs	0	0	128	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	5	0	0	0
WaterSMART: Remote Sensing	0	0	0	0	0	400	0
Ecosystem Services: Landscape and Climate Conditions	0	0	0	0	0	200	0
Resilient Coastal Landscapes and Communities: Coastal Land Use Change and Sea-Level Rise	0	0	0	0	0	200	0
Natural Hazard Science for Disaster Response: Scenario Planning and Response	0	0	0	0	0	300	0
Subtotal: Land Use Change	***78,386***	***78,386***	***451***	***19***	***0***	***30,400***	***109,256***
Activity Total, Climate and Land Use Change	**131,975**	**135,975**	**844**	**36**	**0**	**54,973**	**191,828**

Budget at a Glance (Dollars in Thousands)							
	2014 Actual	2015 Enacted	Fixed Costs	Seasonal Federal Health Benefit	Internal Transfers	Program Changes	2016 Budget Request
Energy, Minerals, and Environmental Health							
Mineral and Energy Resources							
Mineral Resources	**45,931**	**45,931**	**697**	**90**	**0**	**999**	**47,717**
Fixed Costs	0	0	697	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	90	0	0	0
Critical Minerals	0	0	0	0	0	2,440	0
Sun Setting Activities	0	0	0	0	0	-2,000	0
R&D to Address Environmental Impacts of Minerals Development	0	0	0	0	0	559	0
Energy Resources	**25,970**	**24,895**	**308**	**40**	**0**	**2,825**	**28,068**
Fixed Costs	0	0	308	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	40	0	0	0
Alternative Energy Permitting on Federal Lands	0	0	0	0	0	875	0
ERP Pubs Contributions	0	0	0	0	0	-200	0
All-of-the-Above Energy: Renewable Energy - Geothermal	0	0	0	0	0	200	0
Ecosystem Services: Evaluating Green Infrastructure Investment	0	0	0	0	0	250	0
Ecosystem Services: Enhancing Resilience in Coastal Infrastructure	0	0	0	0	0	150	0
Unconventional Oil and Gas Research	0	0	0	0	0	1,550	0
Subtotal: Mineral and Energy Resources	***71,901***	***70,826***	***1,005***	***130***	***0***	***3,824***	***75,785***
Environmental Health							
Contaminant Biology	**9,647**	**10,197**	**133**	**17**	**0**	**1,723**	**12,070**
Fixed Costs	0	0	133	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	17	0	0	0
Environmental Impacts of Uranium Mining	0	0	0	0	0	273	0
Critical Landscapes: Columbia River	0	0	0	0	0	50	0
Unconventional Oil and Gas Research	0	0	0	0	0	1,400	0
Toxic Substance Hydrology	**9,967**	**11,248**	**132**	**17**	**0**	**4,050**	**15,447**
Fixed Costs	0	0	132	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	17	0	0	0
Environmental Impacts of Uranium Mining	0	0	0	0	0	1,750	0
Emerging Contaminants & Chemical Mixtures	0	0	0	0	0	700	0
Critical Landscapes: Columbia River	0	0	0	0	0	50	0
Unconventional Oil and Gas Research	0	0	0	0	0	250	0
Resilient Coastal Landscapes and Communities: Contaminant Network Along Northeast Coast	0	0	0	0	0	1,300	0
Subtotal: Environmental Health	***19,614***	***21,445***	***265***	***34***	***0***	***5,773***	***27,517***
Activity Total, Energy, Minerals and Environmental Health	**91,515**	**92,271**	**1,270**	**164**	**0**	**9,597**	**103,302**

Budget at a Glance (Dollars in Thousands)							
	2014 Actual	2015 Enacted	Fixed Costs	Seasonal Federal Health Benefit	Internal Transfers	Program Changes	2016 Budget Request
Natural Hazards							
Earthquake Hazards	**53,803**	**59,503**	**530**	**121**	**0**	**-2,202**	**57,952**
Fixed Costs	0	0	530	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	121	0	0	0
Natural Hazard Science for Disaster Response: EEW and Event Characterization	0	0	0	0	0	-1,502	0
Precision Monitoring for Non-Seismic Fault Activity	0	0	0	0	0	-700	0
Volcano Hazards	**23,121**	**25,121**	**316**	**72**	**0**	**200**	**25,709**
Fixed Costs	0	0	316	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	72	0	0	0
All-of-the-Above Energy: Renewable Energy - Geothermal	0	0	0	0	0	200	0
Natural Hazard Science for Disaster Response: Response to Volcanic Hazards	0	0	0	0	0	0	0
Landslide Hazards	**3,485**	**3,485**	**44**	**10**	**0**	**500**	**4,039**
Fixed Costs	0	0	44	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	10	0	0	0
Natural Hazard Science for Disaster Response: Landslide Response	0	0	0	0	0	500	0
Global Seismographic Network	**4,853**	**4,853**	**21**	**5**	**0**	**4,920**	**9,799**
Fixed Costs	0	0	21	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	5	0	0	0
Natural Hazard Science for Disaster Response: GSN Primary Sensor Deployment	0	0	0	0	0	4,920	0
Geomagnetism	**1,888**	**1,888**	**29**	**7**	**0**	**1,700**	**3,624**
Fixed Costs	0	0	29	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	7	0	0	0
Natural Hazard Science for Disaster Response: Improved Geomagnetic Monitoring to Support Space Weather Nowcasting	0	0	0	0	0	1,700	0
Coastal & Marine Geology	**41,336**	**40,336**	**498**	**113**	**174**	**4,109**	**45,230**
Fixed Costs	0	0	498	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	113	0	0	0
Critical Landscapes: Arctic	0	0	0	0	0	2,000	0
Resilient Coastal Landscapes and Communities: Resilience & Vulnerability	0	0	0	0	0	2,109	0
Internal Transfer: Moved from Water Availability and Use Science	0	0	0	0	174	0	0
Activity Total, Natural Hazards	**128,486**	**135,186**	**1,438**	**328**	**174**	**9,227**	**146,353**

Budget at a Glance (Dollars in Thousands)							
	2014 Actual	2015 Enacted	Fixed Costs	Seasonal Federal Health Benefit	Internal Transfers	Program Changes	2016 Budget Request
Water Resources							
Water Availability and Use Science Program	**38,544**	**40,919**	**619**	**187**	**-174**	**5,207**	**46,758**
Fixed Costs	0	0	619	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	187	0	0	0
WaterSMART: Water Use Research	0	0	0	0	0	1,000	0
HR&D Monitoring and Assessments	0	0	0	0	0	-550	0
WaterSMART: Streamflow Information	0	0	0	0	0	400	0
WaterSMART: National Hydrologic Model	0	0	0	0	0	750	0
WaterSMART: Water Use Information	0	0	0	0	0	3,000	0
Model Development and Research	0	0	0	0	0	-444	0
WaterSMART: Drought	0	0	0	0	0	301	0
Critical Landscapes: Arctic	0	0	0	0	0	750	0
Internal Transfer: Moved to Coastal and Marine Geology	0	0	0	0	-174	0	0
Groundwater and Streamflow Information Program	**66,069**	**69,707**	**582**	**216**	**0**	**3,028**	**73,533**
Fixed Costs	0	0	582	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	216	0	0	0
Tribes	0	0	0	0	0	500	0
WaterSMART: Groundwater Network	0	0	0	0	0	1,000	0
HR&D Monitoring and Assessments	0	0	0	0	0	-100	0
WaterSMART: Streamflow Information	0	0	0	0	0	928	0
Natural Hazard Science for Disaster Response: Expand Use of Streamgages	0	0	0	0	0	700	0
National Water Quality Program	**96,168**	**94,141**	**1,338**	**450**	**-2,191**	**2,349**	**96,087**
Fixed Costs	0	0	1,338	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	450	0	0	0
Water Quality Monitoring	0	0	0	0	0	-1,000	0
HR&D Monitoring and Assessments	0	0	0	0	0	-350	0
Enhanced Cooperative Activities and Urban Waters	0	0	0	0	0	717	0
Support NAWQA Cycle Three	0	0	0	0	0	1,881	0
Internal Transfer: Moved to Environments	0	0	0	0	-2,191	0	0
Critical Landscapes: Puget Sound	0	0	0	0	0	100	0
Critical Landscapes: Upper Mississippi River	0	0	0	0	0	100	0
Unconventional Oil and Gas Research	0	0	0	0	0	901	0
Water Resources Research Act Program	**6,500**	**6,500**	**0**	**0**	**0**	**0**	**6,500**
Program Amount	6,500	6,500	0	0	0	0	6,500
Activity Total, Water Resources	**207,281**	**211,267**	**2,539**	**853**	**-2,365**	**10,584**	**222,878**

Budget at a Glance
(Dollars in Thousands)

	2014 Actual	2015 Enacted	Fixed Costs	Seasonal Federal Health Benefit	Internal Transfers	Program Changes	2016 Budget Request
Core Science Systems							
Science Synthesis, Analysis and Research Program	**24,314**	**24,299**	**236**	**12**	**0**	**1,350**	**25,897**
Fixed Costs	0	0	236	0	0	0	0
Pollinators	0	0	0	0	0	350	0
Big Earth Data: Observations and Measurements	0	0	0	0	0	500	0
WaterSMART: Drought	0	0	0	0	0	200	0
Ecosystem Services: Decision Support Tools	0	0	0	0	0	300	0
Healthcare for Seasonal Workers	0	0	0	12	0	0	0
National Cooperative Geologic Mapping Program	**24,397**	**24,397**	**230**	**12**	**0**	**700**	**25,339**
Fixed Costs	0	0	230	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	12	0	0	0
Resilient Coastal Landscapes and Communities: Sea-level Rise Models	0	0	0	0	0	500	0
Natural Hazard Science for Disaster Response: Sinkhole Response	0	0	0	0	0	200	0
National Geospatial Program	**60,096**	**58,532**	**656**	**34**	**0**	**16,509**	**75,731**
Fixed Costs	0	0	656	0	0	0	0
WaterSMART: National Hydrography Database	0	0	0	0	0	1,000	0
Healthcare for Seasonal Workers	0	0	0	34	0	0	0
3D Elevation: Alaska Mapping and Map Modernization	0	0	0	0	0	1,322	0
3D Elevation: National Enhancement	0	0	0	0	0	1,387	0
3D Elevation: NHD/Landscape Level Assessments - Chesapeake Bay	0	0	0	0	0	500	0
3D Elevation: Coastal lidar	0	0	0	0	0	500	0
Critical Landscapes: Columbia River	0	0	0	0	0	350	0
Critical Landscapes: Puget Sound	0	0	0	0	0	450	0
Community Resilience Toolkit	0	0	0	0	0	11,000	0
Activity Total, Core Science Systems	**108,807**	**107,228**	**1,122**	**58**	**0**	**18,559**	**126,967**

Budget at a Glance (Dollars in Thousands)							
	2014 Actual	2015 Enacted	Fixed Costs	Seasonal Federal Health Benefit	Internal Transfers	Program Changes	2016 Budget Request
Science Support							
Administration and Management	**86,985**	**84,192**	**2,092**	**118**	**0**	**4,197**	**90,599**
Fixed Costs	0	0	1,060	0	0	0	0
DOI Science Coordination	0	0	0	0	0	200	0
Outreach to Underserved Communities	0	0	0	0	0	200	0
Mendenhall Program Postdocs	0	0	0	0	0	500	0
Youth & Education in Science	0	0	0	0	0	1,000	0
Tribal Science Coordination	0	0	0	0	0	300	0
Support Science Mission, Infrastructure Capacity to Support Science	0	0	0	0	0	1,997	0
Fixed Costs: Working Capital Fund	0	0	1,046	0	0	0	0
Fixed Costs: Works Comp	0	0	-24	0	0	0	0
Fixed Costs: Unemployment Comp	0	0	10	0	0	0	0
Healthcare for Seasonal Workers	0	0	0	118	0	0	0
Information Services	**23,719**	**21,419**	**171**	**19**	**0**	**620**	**22,229**
Fixed Costs	0	0	171	0	0	0	0
Support Science Mission, Infrastructure Capacity to Support Science	0	0	0	0	0	620	0
Healthcare for Seasonal Workers	0	0	0	19	0	0	0
Activity Total, Science Support	**110,704**	**105,611**	**2,263**	**137**	**0**	**4,817**	**112,828**
Facilities							
Rental Payments and Operations & Maintenance	**93,141**	**93,141**	**-2,408**	**0**	**0**	**16,314**	**107,047**
Fixed Costs	0	0	98	0	0	0	0
Reducing the Facilities Footprint - Cost Savings and Innovation Plan (CSIP)	0	0	0	0	0	11,602	0
Sustainability Investments	0	0	0	0	0	2,000	0
Fixed Costs: Rental Payments	0	0	-2,506	0	0	0	0
Operations and Maintenance Stewardship	0	0	0	0	0	2,712	0
Deferred Maintenance and Capital Improvement	**7,280**	**7,280**	**0**	**0**	**0**	**0**	**7,280**
Activity Total, Facilities	**100,421**	**100,421**	**-2,408**	**0**	**0**	**16,314**	**114,327**
Grand Total, SIR	**1,032,000**	**1,045,000**	**8,969**	**3,582**	**0**	**137,231**	**1,194,782**

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USGS Accounts

Analysis by Account and Activity
($ in Thousands)

Activity/Subactivity/Program Element	2014 Actual		2015 Enacted		Fixed Costs & Related Changes (+/-) *		Internal Transfers (+/-)		Program Changes (+/-)		2016 Budget Request		Change from 2105 (+/-)	
	FTE	Amount	FTE	Amount	FTE	Amount	FTE	Amount	FTE	Amount	FTE	Amount	FTE	Amount
Appropriation: Surveys, Investigations, and Research														
Ecosystems	945	$152,811	940	$157,041	0	$3,907	18	$2,191	44	$13,160	1,002	$176,299	62	$19,258
Climate and Land Use Change	376	$131,975	381	$135,975	0	$880	0	$0	58	$54,973	439	$191,828	58	$55,853
Energy, Minerals, and Environmental Health	540	$91,515	549	$92,271	0	$1,434	0	$0	46	$9,597	595	$103,302	46	$11,031
Natural Hazards	617	$128,486	622	$135,186	0	$1,766	1	$174	11	$9,227	634	$146,353	12	$11,167
Water Resources	1433	$207,281	1434	$211,267	0	$3,392	-19	-$2,365	21	$10,584	1,436	$222,878	2	$11,611
Core Science Systems	516	$108,807	470	$107,228	0	$1,180	0	$0	8	$18,559	478	$126,967	8	$19,739
Science Support	493	$110,704	477	$105,611	0	$2,400	0	$0	19	$4,817	496	$112,828	19	$7,217
Facilities	62	$100,421	62	$100,421	0	-$2,408	0	$0	0	$16,314	62	$114,327	0	$13,906
Total, USGS	**4,982**	**$1,032,000**	**4,935**	**$1,045,000**	**0**	**$12,551**	**0**	**$0**	**207**	**$137,231**	**5,142**	**$1,194,782**	**207**	**$149,782**

* Includes Seasonal Federal Health Benefit Increase

United States Geological Survey

Federal Funds

General and special funds:

SURVEYS, INVESTIGATIONS, AND RESEARCH

For expenses necessary for the United States Geological Survey to perform surveys, investigations, and research covering topography, geology, hydrology, biology, and the mineral and water resources of the United States, its territories and possessions, and other areas as authorized by 43 U.S.C. 31, 1332, and 1340; classify lands as to their mineral and water resources; give engineering supervision to power permittees and Federal Energy Regulatory Commission licensees; administer the minerals exploration program (30 U.S.C. 641); conduct inquiries into the economic conditions affecting mining and materials processing industries (30 U.S.C. 3, 21a, and 1603; 50 U.S.C. 98g(1)) and related purposes as authorized by law; and to publish and disseminate data relative to the foregoing activities; [$1,045,000,000] *$1,194,782,000*, to remain available until September 30, [2016] *2017*; of which [$53,337,189] *$77,637,189* shall remain available until expended for satellite operations; and of which $7,280,000 shall be available until expended for deferred maintenance and capital improvement projects that exceed $100,000 in cost: *Provided*, That none of the funds provided for the ecosystem research activity shall be used to conduct new surveys on private property, unless specifically authorized in writing by the property owner: *Provided further*, That no part of this appropriation shall be used to pay more than one-half the cost of topographic mapping or water resources data collection and investigations carried on in cooperation with States and municipalities.

Appropriation Language and Citations

For expenses necessary for the United States Geological Survey to perform surveys, investigations, and research covering topography, geology, hydrology, biology, and the mineral and water resources of the United States,

- **43 U.S.C. 31(a)** provides for establishment of the Office of the Director of the Geological Survey, under the Interior Department, and that this officer shall have direction of the Geological Survey, and the classification of the public lands and examination of the geological structure, mineral resources, and products of the national domain.

A full listing of USGS appropriation language and citations is available at the USGS Office of Budget, Planning, and Integration Web site, under Resources and Tools.

Web site: *http://www.usgs.gov/budget/resources_tools.asp*

Expiring Authorization Citation	
Bureau/Office Name	USGS/Energy, Minerals, and Environmental Health
Program Name	Energy Resources Program
Citation	50 U.S.C. 167n, P.L. 113-40
Title of Legislation	Helium Stewardship Act of 2013
Last Year of Authorization	2015
BY Budget Request ($000)	$ 28,068
Explanation of Authorization Requirement for BY	Completion of Helium Gas Resource Assessement
Program Description	Not later than 2 years after October 2, 2013, the Secretary, acting through the Director of the United States Geological Survey, shall-(1) in coordination with appropriate heads of State geological surveys-(A) complete a national helium gas assessment that identifies and quantifies the quantity of helium, including the isotope helium-3, in each reservoir, including assessments of the constituent gases found in each helium resource, such as carbon dioxide, nitrogen, and natural gas; and(B) make available the modern seismic and geophysical log data for characterization of the Bush Dome Reservoir;(2) in coordination with appropriate international agencies and the global geology community, complete a global helium gas assessment that identifies and quantifies the quantity of the helium, including the isotope helium-3, in each reservoir;(3) in coordination with the Secretary of Energy, acting through the Administrator of the Energy Information Administration, complete- (A) an assessment of trends in global demand for helium, including the isotope helium-3; (B) a 10-year forecast of domestic demand for helium across all sectors, including scientific and medical research, commercial, manufacturing, space technologies, cryogenics, and national defense; and (C) an inventory of medical, scientific, industrial, commercial, and other uses of helium in the United States, including Federal uses, that identifies the nature of the helium use, the amounts required, the technical and commercial viability of helium recapture and recycling in that use, and the availability of material substitutes wherever possible; and (4) submit to the Committee on Energy and Natural Resources of the Senate and the Committee on Natural Resources of the House of Representatives a report describing the results of the assessments required under this paragraph.

Expiring Authorization Citation	
Bureau/Office Name	USGS/Natural Hazards
Program Name	Earthquakes Hazards Program
Citation	P.L. 108-360; 42 U.S.C. Sec. 7701-7709
Title of Legislation	National Earthquake Hazards Reduction Program Reauthorization Act of 2004
Last Year of Authorization	2009
BY Budget Request ($000)	$57,952
Explanation of Authorization Requirement for BY	No individual programmatic authorization is necessary for the USGS to continue this effort
Program Description	Monitoring, research, assessment and characterization of earthquake hazards

Expiring Authorization Citation	
Bureau/Office Name	USGS/Core Science Systems
Program Name	Science Synthesis, Analysis, and Research
Citation	42 U.S.C. 15908 sec 351, P.L. 109-58
Title of Legislation	National Geologic and Geophysical Data Preservation Program Act of 2005
Last Year of Authorization	2010
BY Budget Request ($000)	$25,897
Explanation of Authorization Requirement for BY	No individual programmatic authorization is necessary for the USGS to continue this effort
Program Description	SEC. 351. Preservation of Geological and Geophysical Data Program.—The Secretary (Interior) shall carry out a National Geological and Geophysical Data Preservation Program in accordance with this section—(1) Establishment.—The Secretary shall establish, as a component of the Program, a data archive system to provide for the storage, preservation, and archiving of subsurface, surface, geological, geophysical, and engineering data and samples. The Secretary, in consultation with the Advisory Committee, shall develop guidelines relating to the data archive system, including the types of data and samples to be preserved.

Expiring Authorization Citation	
Bureau/Office Name	USGS/Water Resources Program
Program Name	Water Resources Research Act Program
Citation	42 U.S.C. 10301 - 10303, P.L. 109-471
Title of Legislation	Water Resources Research Act Amendments of 2006
Last Year of Authorization	2011
BY Budget Request ($000)	$ 6,500
Explanation of Authorization Requirement for BY	No individual programmatic authorization is necessary for the USGS to continue this effort
Program Description	Sec. 2 (a) Scope of Research; Other Activities; Cooperation and Coordination. –Section 104(b)(1) of the Water Resources Research Act of 1984 (42 U.S.C. 10303(b)(1) is amended to read as follows: “plan, conduct, or otherwise arrange for competent applied and peer reviewed research that fosters: improvements in water supply reliability; the exploration of new ideas that address water problems, or expand understanding of water and water related phenomena; the entry of new research scientists, engineers, and technicians into water resources fields; and the dissemination of research results to water managers and the public.

Administrative Provisions

From within the amount appropriated for activities of the United States Geological Survey such sums as are necessary shall be available for contracting for the furnishing of topographic maps and for the making of geophysical or other specialized surveys when it is administratively determined that such procedures are in the public interest; construction and maintenance of necessary buildings and appurtenant facilities; acquisition of lands for gauging stations and observation wells; expenses of the United States National Committee for Geological Sciences; and payment of compensation and expenses of persons employed by the Survey duly appointed to represent the United States in the negotiation and administration of interstate compacts: *Provided*, That activities funded by appropriations herein made may be accomplished through the use of contracts, grants, or cooperative agreements as defined in section 6302 of title 31, United States Code: *Provided further*, That the United States Geological Survey may enter into contracts or cooperative agreements directly with individuals or indirectly with institutions or nonprofit organizations, without regard to 41 U.S.C. 6101, for the temporary or intermittent services of students or recent graduates, who shall be considered employees for the purpose of chapters 57 and 81 of title 5, United States Code, relating to compensation for travel and work injuries, and chapter 171 of title 28, United States Code, relating to tort claims, but shall not be considered to be Federal employees for any other purposes.

Administrative Provisions Language and Citations

A full listing of USGS appropriation language and citations is available at the USGS Office of Budget, Planning, and Integration Web site, under Resources and Tools.

Web site: *http://www.usgs.gov/budget/resources_tools.asp*

Summary Of Requirements
($ in Thousands)

Activity/Subactivity/Program Element	2014 Actual	FY 2015 Enacted		Fixed Costs & Related Changes (+/-) *	Internal Transfers (+/-)	Program Changes (+/-)		2016 Budget Request		Change from 2105 (+/-)	
	Amount	Total *FTE*	Amount			*FTE*	Amount	*FTE*	Amount	*FTE*	Amount
Appropriation: Surveys, Investigations, and Research											
Ecosystems	20,473	120	20,473	495	0	6	1,210	126	22,178	6	1,705
Status and Trends	20,886	129	20,886	586	0	8	3,950	137	25,422	8	4,536
Fisheries Program	44,757	289	45,257	1,264	0	1	150	290	46,671	1	1,414
Wildlife Program	36,244	177	36,224	740	2,191	34	3,600	211	42,755	34	6,531
Environments Program	13,080	73	16,830	201	0	4	2,250	77	19,281	4	2,451
Invasive Species	17,371	152	17,371	621	0	9	2,000	161	19,992	9	2,621
Cooperative Research Units	**152,811**	**940**	**157,041**	**3,907**	**2,191**	**62**	**13,160**	**1,002**	**176,299**	**62**	**19,258**
Ecosystems Total											
Climate and Land Use Change											
Climate Variability											
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	23,735	42	26,735	88	0	14	10,580	56	37,403	14	10,668
Climate Research & Development	20,495	120	21,495	268	0	14	4,893	134	26,656	14	5,161
Carbon Sequestration	9,359	27	9,359	54	0	23	9,100	50	18,513	23	9,154
Subtotal	*53,589*	*189*	*57,589*	*410*	*0*	*51*	*24,573*	*240*	*82,572*	*51*	*24,983*
Land Use Change											
Land Remote Sensing	67,894	141	67,894	337	0	2	29,300	143	97,531	2	29,637
Land Change Science	10,492	51	10,492	133	0	5	1,100	56	11,725	5	1,233
Subtotal	*78,386*	*192*	*78,386*	*470*	*0*	*7*	*30,400*	*199*	*109,256*	*7*	*30,870*
Climate and Land Use Change Total	**131,975**	**381**	**135,975**	**880**	**0**	**58**	**54,973**	**439**	**191,828**	**58**	**55,853**
Energy, Minerals, and Environmental Health											
Mineral and Energy Resources											
Mineral Resources	45,931	291	45,931	787	0	14	999	305	47,717	14	1,786
Energy Resources	25,970	140	24,895	348	0	9	2,825	149	28,068	9	3,173
Subtotal	*71,901*	*431*	*70,826*	*1,135*	*0*	*23*	*3,824*	*454*	*75,785*	*23*	*4,959*
Environmental Health											
Contaminant Biology	9,647	57	10,197	150	0	6	1,723	63	12,070	6	1,873
Toxic Substance Hydrology	9,967	61	11,248	149	0	17	4,050	78	15,447	17	4,199
Subtotal	*19,614*	*118*	*21,445*	*299*	*0*	*23*	*5,773*	*141*	*27,517*	*23*	*6,072*
Energy, Minerals, and Environmental Health Total	**91,515**	**549**	**92,271**	**1,434**	**0**	**46**	**9,597**	**595**	**103,302**	**46**	**11,031**
Natural Hazards											
Earthquake Hazards	53,803	236	59,503	651	0	-4	-2,202	232	57,952	-4	-1,551
Volcano Hazards	23,121	140	25,121	388	0	1	200	141	25,709	1	588
Landslide Hazards	3,485	19	3,485	54	0	2	500	21	4,039	2	554
Global Seismographic Network	4,853	11	4,853	26	0	2	4,920	13	9,799	2	4,946
Geomagnetism	1,888	12	1,888	36	0	3	1,700	15	3,624	3	1,736
Coastal & Marine Geology	41,336	204	40,336	611	174	8	4,109	212	45,230	8	4,894
Natural Hazards Total	**128,486**	**622**	**135,186**	**1,766**	**174**	**12**	**9,227**	**634**	**146,353**	**12**	**11,167**
Water Resources											
Water Availability and Use Science	38,544	298	40,919	806	-174	4	5,207	302	46,758	4	5,839
Groundwater and Streamflow Information Program	66,069	393	69,707	798	0	8	3,028	401	73,533	8	3,826
National Water Quality	96,168	741	94,141	1,788	-2,191	-10	2,349	731	96,087	-10	1,946
Water Resources Research Act Program	6,500	2	6,500	0	0	0	0	2	6,500	0	0
Water Resources Total	**207,281**	**1,434**	**211,267**	**3,392**	**-2,365**	**2**	**10,584**	**1,436**	**222,878**	**2**	**11,611**
Core Science Systems											
Science Synthesis, Analysis and Research Program	24,314	98	24,299	248	0	0	1,350	98	25,897	0	1,598
National Cooperative Geologic Mapping Program	24,397	112	24,397	242	0	2	700	114	25,339	2	942
National Geospatial Program	60,096	260	58,532	690	0	6	16,509	266	75,731	6	17,199
Core Science Systems Total	**108,807**	**470**	**107,228**	**1,180**	**0**	**8**	**18,559**	**478**	**126,967**	**8**	**19,739**

Summary Of Requirements
($ in Thousands)

Activity/Subactivity/Program Element	2014 Actual	FY 2015 Enacted		Fixed Costs & Related Changes (+/-) *	Internal Transfers (+/-)	Program Changes (+/-)		2016 Budget Request		Change from 2105 (+/-)	
	Amount	Total *FTE*	Amount			*FTE*	Amount	*FTE*	Amount	*FTE*	Amount
Science Support											
Administration and Management	86,985	411	84,192	2,210	0	17	4,197	428	90,599	17	6,407
Information Services	23,719	66	21,419	190	0	2	620	68	22,229	2	810
Administration and Enterprise Information Total	**110,704**	**477**	**105,611**	**2,400**	**0**	**19**	**4,817**	**496**	**112,828**	**19**	**7,217**
Facilities											
Rental Payments and Operations & Maintenance	93,141	62	93,141	-2,408	0	0	16,314	62	107,047	0	13,906
Deferred Maintenance and Capital Improvement	7,280	0	7,280	0	0	0	0	0	7,280	0	0
Facilities Total	**100,421**	**62**	**100,421**	**-2,408**	**0**	**0**	**16,314**	**62**	**114,327**	**0**	**13,906**
Total, USGS	**1,032,000**	**4,935**	**1,045,000**	**12,551**	**0**	**207**	**137,231**	**5,142**	**1,194,782**	**207**	**149,782**

US Geological Survey

Justification of Fixed Costs and Internal Realignments

(Dollars In Thousands)

Fixed Cost Changes and Projections	2015 Total or Change	2015 to 2016 Change
Change in Number of Paid Days This column reflects changes in pay associated with the change in the number of paid days between the 2015 and 2016.	+0	+2,439
Pay Raise The change reflects the salary impact of programmed pay raise increases.	+6,239	+7,723
Seasonal Federal Health Benefit Increase The change reflects changes in the fixed cost portion of the Seasonal Health Benefits Model.	+0	+46
Employer Contribution to FERS The change reflects the directed increase of 0.5% in employer's contribution to the Federal Employee Retirement System.	+0	+235
Departmental Working Capital Fund The change reflects expected changes in the charges for centrally billed Department services and other services through the Working Capital Fund. These charges are detailed in the Budget Justification for Department Management.	-889	+1,046
Departmental Working Capital Fund ITT The change reflects expected changes in the charges for centrally billed Department services through the Working Capital Fund.	+355	+0
Worker's Compensation Payments The adjustment is for changes in the costs of compensating injured employees and dependents of employees who suffer accidental deaths while on duty. Costs for 2016 will reimburse the Department of Labor, Federal Employees Compensation Fund, pursuant to 5 U.S.C. 8147(b) as amended by Public Law 94-273.	-343	-24
Unemployment Compensation Payments The adjustment is for projected changes in the costs of unemployment compensation claims to be paid to the Department of Labor, Federal Employees Compensation Account, in the Unemployment Trust Fund, pursuant to Public Law 96-499.	-38	+10
Rental Payments The adjustment is for changes in the costs payable to General Services Administration (GSA) and others resulting from changes in rates for office and non-office space as estimated by GSA, as well as the rental costs of other currently occupied space. These costs include building security; in the case of GSA space, these are paid to Department of Homeland Security (DHS). Costs of mandatory office relocations, i.e. relocations in cases where due to external events there is no alternative but to vacate the currently occupied space, are also included.	+853	-2,506

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Ecosystems

Activity: Ecosystems

		2014 Actual	2015 Enacted	2016 Fixed Costs and Related Changes (+/-)*	2016 Internal Transfer	2016 Program Changes	2016 Budget Request	Change from 2015 (+/-)
Status and Trends ($000)		20,473	20,473	495	0	1,210	22,178	1,705
	FTE	120	120	0	0	6	126	6
Fisheries Program (($000)		20,886	20,886	586	0	3,950	25,422	4,536
	FTE	131	129	0	0	8	137	8
Wildlife Program ($000)		44,757	45,257	1,264	0	150	46,671	1,414
	FTE	294	289	0	0	1	290	1
Environments Program ($000)		36,244	36,224	740	2,191	3,600	42,755	6,531
	FTE	185	177	0	18	16	211	34
Invasive Species ($000)		13,080	16,830	201	0	2,250	19,281	2,451
	FTE	63	73	0	0	4	77	4
Cooperative Research Units ($000)		17,371	17,371	621	0	2,000	19,992	2,621
	FTE	152	152	0	0	9	161	9
Total Requirements ($000)		**152,811**	**157,041**	**3,907**	**2,191**	**13,160**	**176,299**	**19,258**
Total FTE		**945**	**940**	**0**	**18**	**44**	**1,002**	**62**

**Fixed Costs are $1,901 and Seasonal Federal Health Benefits are $2,006*

Summary of Program Changes

Request Component	($000)	FTE	Page
Status and Trends	**1,210**	**6**	
Pollinators	1,210	6	C-27
Fisheries Program	**3,950**	**8**	
Great Lakes Fisheries Assessments	250	0	C-52
Unconventional Oil and Gas Research	1,200	4	C-71
WaterSMART: Ecological Flows	2,500	4	C-6
Wildlife Program	**150**	**1**	
All-of-the-Above Energy: Renewable Energy - Wind & Solar	150	1	C-71
Environments Program	**3,600**	**16**	
Critical Landscapes: Arctic	700	5	C-19
Critical Landscapes: Columbia River	150	0	C-22
Critical Landscapes: Puget Sound	200	0	C-23
Critical Landscapes: Sage Steppe Landscape	1,000	5	C-24
Ecosystem Services: National Ecosystems Framework	450	0	C-46
Natural Hazard Science for Disaster Response: Wildfire Response	500	2	C-39
OCS Ecosystems Decisions	300	2	C-54
WaterSMART: Drought	300	2	C-12
Invasive Species	**2,250**	**4**	
Brown Tree Snakes	250	0	C-26
New and Emerging Invasives of National Concern	2,000	4	C-26
Cooperative Research Units	**2,000**	**9**	
CRU Enhanced Support and Scientists for Tomorrow	2,000	9	C-54
Total Program Change	**13,160**	**44**	

Justification of Program Changes

The 2016 Budget Request for Ecosystems is $176,299,000 and 1,002 FTE, a net change of +$19,258,000 and +62 FTE from the 2015 Enacted. For more information on the Ecosystems Mission Area changes, please see Section C, Program Changes as indicated in the table.

Activity Summary

The Ecosystems activity is comprised of six subactivities—

- Status and Trends *(http://www.usgs.gov/ecosystems/status_trends)*
- Fisheries Program (*http://www.usgs.gov/ecosystems/fisheries/index.html*)
- Wildlife Program *(http://www.usgs.gov/ecosystems/wildlife/index.html)*
- Environments Program *(http://www.usgs.gov/ecosystems/environments/index.html)*
- Invasive Species (*http://www.usgs.gov/ecosystems/invasive_species/index.html)*
- Cooperative Research Units *(http://www.coopunits.org/Headquarters*)

Ecosystems Mission Area programs provide science support to the Department of the Interior (Interior) bureaus and other partners through research focused on answering management questions and real-world problems. This requires a combination of short- and long-term biological research, survey and monitoring, data analysis and applications, development of new tools and techniques, including decision support and adaptive management. Partnerships with other Federal, State, tribal and private research organizations leverage millions of dollars that result in sustained and healthy community economies, public safety, and well-being by delivering key services to society. This science supports societal needs for commercially valuable fish and wildlife management, water filtration and pollution control, healthy soils, crop pollination, and reduced impact of severe weather events and other natural disasters. Ongoing efforts focus on critical issues such as ecosystem restoration, energy development, coastal resiliency, and fire ecology in places such as the Chesapeake Bay, California Bay-Delta, Puget Sound, Gulf Coast, Sage Steppe Biome, Everglades, Great Lakes, Alaska, Mississippi River Basin, and the Outer Continental Shelf.

As part of its management oversight, the Mission Area has designed and implemented a science portfolio analysis process called Lines of Work in 2014. This tool enables management to assess how appropriated and reimbursable funds are being used to support Ecosystems and Interior goals at USGS science centers. The information gathered enables the Mission Area to make strategic decisions on how and where to support science priorities.

Activity: Ecosystems
Subactivity: Status and Trends

2014 Actual: $20.5 million (120 FTE)
2015 Enacted: $20.5 million (120 FTE)
2016 Request: $22.2 million (126 FTE)

Overview

The living resources of the United States, and the habitats on which they depend, are undergoing constant change due to human and natural influences. To protect and conserve the living resources—plants, animals, habitats, ecosystems—entrusted to their care, land and resource managers must understand the condition, or status (e.g., abundance, distribution, productivity, health), of those resources as well as their trends (i.e., how these variables change over time). Credible information about the status and trends of natural resources is required at a variety of spatial and temporal scales to detect changes that may signal degradation or improvement of natural systems, or to identify new or emerging conditions that signal the need for management action or further investigative research. In addition, status and trends information is required to evaluate the effectiveness of specific management actions, to validate research results and models, and to promote a broad understanding and appreciation of the natural resources that support our society. An understanding of the status and trends of natural resources is also critical to adaptive resource management, a sequential decisionmaking process for continually improving management policies and practices by learning from the outcomes of previous decisions and management actions.

> *"Monarch conservation is a truly intricate issue, requiring consideration of many ecological dimensions. The Monarch Joint Venture is excited that USGS is applying their breadth of science in innovative ways to help manage this iconic species."*
>
> Dr. Karen Oberhauser
> Monarch Joint Venture and University of Minnesota Monarch Lab Director

The Status and Trends Program responds to the monitoring and information needs and requirements of resource management bureaus within Interior (e.g., National Park Service (NPS), Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (FWS), Bureau of Ocean Energy Management (BOEM)), and other science and resource management organizations by designing, developing, and supporting research, monitoring, and assessment activities required for resource management and policy decisions by a variety of stakeholders. Specific goals of the Program are to:

- Describe and track the abundance, distribution, productivity, and health of the Nation's plants, animals, and ecosystems.
- Develop and evaluate inventory and monitoring methods, designs, tools, models, and technologies to measure and track biological status and trends.
- Collaborate with partners to collect, manage, and share data and information to determine and understand biological status and trends.
- Describe and deliver information and synthesis products to meet the needs of stakeholders including natural resource managers, policy- and decisionmakers, researchers, and the public.

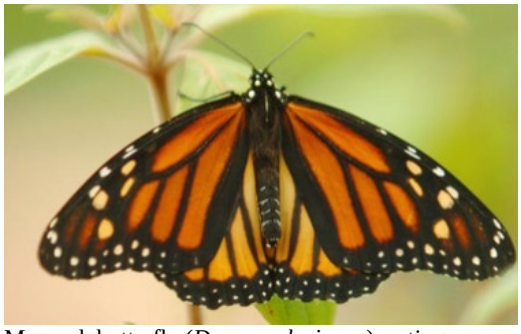
Program funding supports studies on the changing condition of genomes, organisms, biological communities; linkages between populations; predictive modeling; and patterns of resources over time using historic and current data and analyses. The program also supports advances in methods for accurate and unbiased estimates of population status and change through cutting-edge sampling design and statistical methods. Program activities are designed to better understand effectiveness of management practices to improve conditions for key species, and to track and understand the trends of species affected by changes in land use and other environmental drivers. These data are useful for resource managers who need to know how and where to focus their efforts and resources.

Program Performance

Large Scale Conservation Challenges and the American Pika: Small Mammal in a Big World – The USGS leads a multi-partner team that includes the NPS, BLM, Department of Defense, the U. S. Forest Service (USFS), State wildlife agencies, universities, and non-governmental organizations to understand the status of a Western mountain icon, the American pika. In 2014, scientists documented new locations throughout the Great Basin where populations of pikas have shifted upslope to higher elevations than ever before, and they identified several locations where populations of pikas were locally eradicated. In 2015, research is focused on understanding effects of drought and behavioral plasticity on the sustainability of pika populations and, in 2016, research will expand to include work in the Greater Yellowstone Ecosystem, Glacier National Park, northeastern California, and at the species' southern distributional limit in Utah and New Mexico. These results are informing conservation and decisionmaking by a variety of State and Federal resource management agencies in the intermountain West, and are being used as a model for understanding challenges and successes of broad scale conservation programs across the globe.

Habitat of the American pika in the Ruby Mountains Wilderness Area, Nevada

Monarch Butterfly Conservation Science – The Monarch Butterfly is an iconic North American species, and is one of the few insects known to migrate long distances. The Monarch's eastern population flies to Mexico for the winter, and then travels to the United States and southern Canada to breed during the spring and summer. Recently the Monarch has experienced significant population declines, with numbers on the wintering grounds down about 90 percent. To address these declines, the governments of the United States, Mexico, and Canada have agreed to work together to conserve the phenomena of monarch migration. To help support recovery efforts, the USGS convened a partnership of key scientists and stakeholders to answer prominent questions and to provide science that can guide management and conservation actions. This partnership, which was initiated in 2014, has to date produced two preliminary products: (1) a population model designed to understand which factors are most important in driving the size of the population, and (2) an extinction risk assessment to help managers set population targets for recovery. These models will be refined and completed in 2015 and 2016, and by 2016, the partnership will develop a geospatial tool to help determine the most beneficial locations for targeted recovery efforts. These products are designed for use by an interagency working group on monarch conservation, which includes as partners a variety of Federal organizations with an interest in monarch conservation.



Monarch butterfly (*Danaus plexippus*) resting on a native prairie flower at Chase Lake National Wildlife Refuge in North Dakota. (USFWS Photo)

Movement Ecology of Hawaiian Forest Birds: Navigating a Dangerous World – Hawaii's forest birds exist mostly in small forest remnants surrounded by a landscape of degraded habitat and introduced disease. Food resources such as fruit and flowering trees are patchily distributed across the landscape, so the success of native birds depends on their ability to move safely among forest patches to find food. Understanding how birds move successfully among forest remnants is critical, but difficult to achieve across Hawaii's rugged and remote mountain landscape. In 2014, USGS scientists completed the installation of a network of tracking towers—that pick up signals from birds carrying miniature radio transmitters—in the Hakalau Forest National Wildlife Refuge. In 2015 and into 2016, these bird movement data will be combined with demographic data (e.g., survival and number of young produced) to understand how landscape characteristics affect individual birds, and to help resource managers establish management practices that consider both the distribution of birds and their resources across the landscape.

A native I'iwi bird fitted with a radio transmitter will also receive a leg band for identification purposes.

Collaborating to Conserve: Managing Longleaf Pine Savanna in the Real World – The USGS is leading a multi-partner collaboration to develop and test methods to restore freshwater ponds in one of the most extensive ecosystems in North America—the South's longleaf pine-wiregrass savanna. Until recently, these savannas supported one of the richest species diversities outside the tropics. Today, only two percent of the ecosystem exists, and many of its plant and animal species are imperiled. Specifically, several pond-breeding amphibians restricted to these fire-dependent ecosystems are of conservation concern. Because a great deal of uncertainty surrounds the best way to restore these ponds within management constraints, the collaboration is using an adaptive management approach to the restoration. This approach must not only identify and test the most promising management alternatives, but also maximize logistic feasibility and minimize costs. St. Marks National Wildlife Refuge in northwest Florida is the only National Wildlife Refuge where the federally threatened Frosted Flatwoods salamanders persist; as such, this Refuge was chosen as a model for the development of a landscape-level framework for restoration of freshwater ponds across the savanna system. In 2014, the USGS led partners through a structured decisionmaking workshop to assemble the framework for decisions on captive breeding of Flatwoods salamanders for reintroduction, one of the management options in this ambitious project. In 2015 through to 2016, the USGS will lead the development of management options and monitor how well the Flatwoods salamanders respond to their implementation. Results will be used to inform on-the-ground conservation activities and decisionmaking by a variety of partners, including the FWS, USFS, Florida Fish and Wildlife Conservation Commission, University of Missouri, Auburn University, Atlanta Botanical Gardens, and the San Antonio Zoo.

> *"Now I am convinced that it is our best shot at a directed conservation program, with several components, people, and agencies working towards a common goal."*
>
> Mark Mandica
> Amphibian Conservation Coordinator
> Atlanta Botanical Gardens

Restoration of the Northern Great Plains Using Adaptive Management – The USGS developed the Native Prairie Adaptive Management (NPAM) program, a framework to provide annual decision guidance for management of native grasslands in the northern Great Plains. The loss or degradation of about 99 percent of North American prairies coincides with decreasing populations of many animal species that depend on them and, as such, has resulted in one of the most challenging conservation issues of this century. The NPAM integrates geographically diverse information on prairie response to management actions into a system that can inform the management of publicly and privately owned grasslands across a large geographic area. The decision framework was designed to operate adaptively: experiences from past management actions are formally recorded, monitored, and interpreted to improve the quality of subsequent management actions. In 2014, the NPAM improved management decisionmaking on 120 native prairies owned and managed by the FWS in four northern Great Plains States (Montana, South Dakota, North Dakota, and Minnesota). In 2015, the USGS will investigate how the NPAM could be used by other land management agencies, and in 2016 will update decision models to reflect the effectiveness of recent restoration activities.

> *"The beauty of participating in this project is that we are all learning together, working our way toward the answer to a question that was too big for any one of us tackle on our own."*
>
> Todd Frerichs
> Refuge Deputy Project Leader
> Audubon National Wildlife Refuge
> U.S. Fish and Wildlife Service

Activity: Ecosystems
Subactivity: Fisheries Program

2014 Actual: $20.9 million (131 FTE)
2015 Enacted: $20.9 million (129 FTE)
2016 Request: $25.4 million (137 FTE)

Overview

Healthy watersheds and thriving fish populations are vital to the well-being of American society, providing clean water, food, and recreation. Unfortunately, in many places around the United States, fish and the habitats on which they depend are in decline. According to the *National Fish Habitat Action Plan*, almost 40 percent of the Nation's freshwater fish species are considered at risk or vulnerable to extinction. Many saltwater fish are also in decline due to habitat degradation and overfishing. Revenue from recreational fisheries (over 46 million of the Nation's 60 million anglers actively fish in a given year) and commercial fisheries added more than $115.0 billion to our Nation's economy, but this economic engine is at risk as fisheries and habitats decline (reference is American Sportfishing Association, January 2013).

USGS acquired a new state-of-the-art research vessel, Arcticus, designed to conduct lake-wide bottom trawl surveys, hydro-acoustic surveys, gill net surveys, a variety of other science operations, and will operate year-round across the U.S. state boundaries, Canadian waters, and treaty waters of Lakes Huron, Michigan, and Superior.

The USGS Fisheries Program employs world-class scientists to work on cutting-edge research to protect, restore, and enhance our Nation's fisheries and their habitats. The quality, quantity, and breadth of USGS capacity, expertise and geographic coverage are conducive to addressing local, regional, and national questions on aquatic species, communities, and habitats. The Fisheries Program brings the following expertise and capacity to accomplish Ecosystem Mission Area goals and conduct crosscutting research with other USGS Mission Areas, Interior bureaus, and other internal and external partners:

Fish and Aquatic Organism Health
The USGS investigates pathogens and other environmental factors that affect aquatic organism health to support the management, conservation, and restoration of aquatic species. In 2015 and 2016, fish disease research includes both basic and applied science focused on understanding the factors that control the distribution and severity of infectious diseases affecting aquatic organisms and wild fish populations. (*http://www.usgs.gov/ecosystems/fisheries/health.html*)

Genetics, Genomics, and Molecular Biology
Research on genetics and genomics of fish and other aquatic organisms examines and characterizes variation, diversity, taxonomy, and response of individuals, stocks, strains, and populations to environmental change. Molecular tools include the construction of genomic libraries, cloning, sequencing, phylogenetic analysis, recombinant DNA expression systems, standard and quantitative polymerase chain reaction assays, random-amplified polymorphic DNA fingerprinting, DNA probes, and DNA microarray. This capacity provides aquatic resource managers with more accurate methods to identify and discriminate among native, cultured, introduced, and invasive aquatic species, as well as develop science-based conservation and restoration strategies. In 2015 and 2016, USGS research continues to focus on developing new technologies to monitor and evaluate wild fish populations such as brook trout. (*http://www.usgs.gov/ecosystems/fisheries/genetics.html*)

Imperiled Aquatic Species
The USGS conducts studies on biology, life history, population ecology, and conservation strategies for at-risk species and the impacts of environmental stressors on habitat requirements of those species. These investigations lead to more effective and viable conservation actions that reduce the need for formal listing of aquatic species as threatened or endangered and support the goal of downlisting or delisting species. In 2015 and 2016, USGS research will continue to focus on American eel in the Eastern United States and native salmonids in the Western United States.
(*http://www.usgs.gov/ecosystems/fisheries/imperiled.html*)

Restoration Science and Technology
USGS research and technology provides the scientific basis for the adaptive management of aquatic species and aquatic habitats in the United States. The USGS examines the physiology, life history, reproduction, and habitat needs of specific life stages of fish and other aquatic organisms to assist fishery managers to develop techniques to understand, conserve, and restore fish communities. In 2015 and 2016, the USGS will continue to focus on restoration research before and after dam removal at Elwha and Glines Canyon Dams in Washington.
(*http://www.usgs.gov/ecosystems/fisheries/restoration.html*)

Species Diversity and Life History
USGS studies the diversity of aquatic species and their varied life histories and species interactions that represent complex aquatic communities in unique aquatic habitats. They provide scientific syntheses and modeling to develop decision-support and adaptive-management models that incorporate diversity, life history, and species interactions of fish and other aquatic organisms. The USGS forecasts causes of change based on scientific information about diversity, life history, and species interactions that affect the condition and dynamics of aquatic communities. In 2015 and 2016, USGS research will focus on mussels and threatened native fish species, particularly in the southeastern United States.
(*http://www.usgs.gov/ecosystems/fisheries/diversity.html*)

Aquatic Community Ecology
The USGS quantifies and describes functional relationships among aquatic species and habitats to describe aquatic community structure, function, adaptation, and sustainability. By conducting basic research, this science links biology, population genetic diversity, and organism health for fish, native

mussels, and other aquatic organisms in relation to their habitat requirements. This science contributes to understanding ecological processes and patterns of diversity through coordination, development, and standardization of geospatial classification models and maps of national ecosystems. In 2015 and 2016, USGS research will continue to focus on nutrient and sediment reduction provided by aquatic ecosystems.
(*http://www.usgs.gov/ecosystems/fisheries/ecology.html*)

Fish Passage and Dams
USGS research assesses and evaluates management efforts to improve fish passage for anadromous and other migratory fish. Research focuses on fish physiology and behavioral characteristics as well as hydrological conditions that affect successful navigation around barriers by fish and other at-risk aquatic species. In 2015 and 2016, continued research will focus on improving the efficiency and effectiveness of artificial passage structures to improve passage of American eel, shad species, and Pacific salmon.
(*http://www.usgs.gov/ecosystems/fisheries/fish_passage.html*)

River Science
The USGS conducts research on structure and function of large river systems with the goal of sustaining and enhancing fisheries resources in concert with other human uses such as navigation, transportation, energy production, irrigation, and human water supply. The USGS studies the ecology and biodiversity of large rivers and gathers data on the effects of impoundment, urbanization, and changing land and water use on fish, other aquatic species, and their riverine habitats. In 2015 and 2016, USGS research will provide modeling expertise, including aquatic habitat mapping and development of decision-support systems, to investigate population dynamics and biological requirements of at-risk species such as native fish, amphibians, and riparian vegetation.
(*http://www.usgs.gov/ecosystems/fisheries/river_science.html*)

Ecological Flows
The USGS conducts research on the relationship between water quality, quantity and delivery time, and aquatic communities and species of concern. The USGS is in the process of developing tools and approaches for quantifying effects of flow alteration to inform water management. Information includes (1) formal consideration of how different hydraulic models and data densities affect estimates of weighted usable area to address the question of how much study effort is enough; (2) use of landscape ecology concepts in habitat analysis supported by two-dimensional hydraulic models; (3) development of streamflow response and valuation models for riparian vegetation; and (4) development of decision-support system (DSS) and Geographic Information System (GIS)-derived spatial visualization tools to model outputs more accessible to water managers and interested parties.
(*http://www.lsc.usgs.gov/?q=narb-ecological-flows-fishes-mussels*)

Program Performance

Ecological Flows – Developing Adaptive Management Decision Support Systems for Improved Aquatic Habitat Modeling and Water Management – In 2014, the USGS developed Riverine Environmental Flow Decision Support System (REFDSS), a desktop application to allow decisionmakers and scientists to easily view and change the inputs and parameters used in aquatic habitat modeling and

visually inspect how changes to instream flow and modeling parameters will affect model output. The improved decision-support system is accompanied by a user's manual and is programmed to allow the framework to be quickly and easily applied to a new river system where data inputs are available. The tool is enabling stakeholders of the Delaware River Basin to have water management decision-making capabilities at their fingertips. The model has broad transferability to other basins. In 2015, and beyond, the USGS will work to expand research efforts and development of decision support systems in other watersheds. Science and information needs on this topic are critical to states, river basin commissions, federal agencies, tribes, and local communities involved in water management and allocation decisions.

Team evaluating the scrubbing system in the engine room of the motor vessel Indiana Harbor.

Combat the Introduction of Non-native Species into the Great Lakes from Ship Ballast Water Discharges – Introductions of invasive species have had dramatic negative effects on marine, estuarine, and freshwater ecosystems in the United States and abroad. Much of the loss is related to ship ballast movement during trade. The USGS, working with the National Parks Service (NPS) and the American Steamship Company (ASC), developed a treatment method that avoids the use of traditional biocides of concern, yet works effectively in treating ballast water under the extreme conditions of water flow rate and volume common on bulk carriers plying the Great Lakes. In 2014, performance data obtained during initial shipboard trials of the new process carried out on the NPS Motor Vessel (M/V) Ranger III and the ASC M/V Indiana Harbor exceeded expectations. Process details were provided to a naval architecture group (Glosten Associates, Seattle, WA) allowing cost estimates to be established for a full-scale design paid for and on behalf of the ASC. Capital costs were calculated to be less than 60 percent of that established by the U.S. Coast Guard for alternative treatment approaches. The USGS also developed dose/treatment effects of the elevated pH process on over 100 species of environmental bacteria isolated from the Motor Vessel Indiana Harbor's ballast.

Young naturally reproduced lake trout sampled from bottom trawls on board the USGS research vessel Kaho, July 2014. USGS photo.

The USGS continues to work cooperatively with Glosten Associates on a cooperative research and development agreement and work in 2015 and, in 2016, will seek to refine and commercialize a second USGS contribution (U.S. Patent Pending) to ballast water treatment—a hydraulic jet based ballast mixing method for blending treatment reagents in emergency (ship grounding) applications.

Unprecedented Level of Natural Reproduction of Lake Trout – For over 37 years, the USGS has been assessing progress toward the bi-national effort to restore native lake trout to Lake Ontario and providing population and

management research to New York State Department of Environmental Conservation (NYSDEC), Ontario Ministry of Natural Resources (OMNR), and the FWS. Historically, lake trout were the dominant cold-water predator in the Great Lakes, but were extirpated or greatly reduced from all of the lakes by the 1950s. Lake Trout restoration in Lake Ontario has been particularly troublesome due to the effects of invasive fish dominating the forage base. Recently, joint USGS-NYSDEC prey fish assessments coupled with USGS dietary work employing stable isotopes has indicated that in Lake Ontario, the prey fish community and lake trout diets are both shifting toward a more reproductively beneficial composition. Evidence of a response from these shifts was observed in 2014 when USGS-NYSDEC trawl surveys documented over a 10-fold rise in the catch of naturally reproduced young lake trout. At one site in western Lake Ontario, these natural recruits made up over 30 percent of all lake trout sampled.

Emerging Virus Surveillance and Risk Assessment in the Pacific Northwest and Alaska – A surveillance effort and research program for infectious salmon anemia virus (ISAV) was initiated by the United States following unconfirmed reports of ISAV in salmon from British Columbia, Canada. The ISAV has been known to cause high rates of loss to infected fish farms. The USGS participated in the research aspects of this program, in close collaboration with Federal, State and tribal partner agencies, including the FWS, U.S. Department of Agriculture (USDA), National Oceanic and Atmospheric Administration (NOAA), the States of Alaska and Washington, and the Northwest Indian Fisheries Commission. The results of the ISAV research and surveillance illustrated the absence of this exotic virus in Western North America and the risk to Pacific salmon from ISAV is not currently present. The information is important to managers who would need to plan for extensive disinfection and depopulation efforts at hatcheries if the virus were detected. A review of the findings of the surveillance and research activities was requested by and provided to Congress. In addition to ISAV, research efforts were expanded to include other potential viral threats associated with European Atlantic salmon aquaculture, including Piscine reovirus (PRV), Piscine myocarditis virus (PMCV) and Salmonid alphavirus (SAV). To date, there has been no evidence of ISAV, PMCV or SAV found in Washington State trout and salmon stocks but surveillance in Alaska is still ongoing. USGS efforts did confirm presence of PRV in salmon and trout samples obtained from locations in Washington State. PRV has been linked to a serious disease outbreak in farmed European Atlantic salmon but controlled laboratory challenge studies are needed to fully evaluate the risk posed by this virus to native Pacific salmon. Initial results indicate the virus is of little risk to Pacific salmon and further work in 2015 will be extended to determine the relationship between PRV and anemias caused by another salmon virus, Erythrocytic inclusion body syndrome virus. This information is critical to the development of a strategy to manage RV and other emerging diseases that affect both captive and wild populations of Pacific salmon.

Glines Canyon Dam during removal.
Photo by John Gussman

Dam Removal: Elwha and Glines Canyon Dams – In September of 2014 the last portion of the Glines Canyon Dam was removed, finalizing the dam removal phase of the Elwha River Restoration Project. The largest such project of its kind in the world, the undertaking involved the staged removal

of two long-standing dams that had completely blocked fish migration in a river that once supported abundant salmon populations. USGS scientists are working collaboratively with partners, including the FWS, NPS, NOAA and the Lower Elwha Klallam Tribe to measure the ecosystem responses and salmon recolonization in the watershed. In 2014, the USGS and partner organizations completed a series of scientific publications documenting the responses of the river, former reservoirs, estuary, and coastal habitats to the release of over seven million m^3 of sediment during the first two years of dam removal. The downstream effects were large and persistent, as the river experienced suspended sediment loads 10 to 1000 times larger than background, widespread aggradation of one meter in the river channel, and coastal sediment deposition 100 times larger than pre-dam removal background levels. Following dam removal, project scientists have documented anadromous salmon migrating past both former dam sites. The USGS developed and implemented species-specific molecular tools to detect the presence of salmon DNA from environmental water samples, allowing scientists to track the movement of salmon and other migratory fishes into wilderness portions of the watershed upstream of the dams. This next-generation tool is being used with other traditional fisheries techniques to study fish population responses and recolonization of a watershed that is home to ten distinct runs of migratory fish species, including bull trout, eulachon, Chinook salmon and steelhead trout, which are listed as Threatened under the Endangered Species Act.

Unconventional Oil and Gas Development – The USGS conducts research on ecological stressors including physical, chemical, and biological factors that impact the health and integrity of ecosystems and productivity of species. Research includes assessing potential ecological impacts associated with unconventional oil and gas development. In 2015, the USGS Fisheries program will focus research to characterize and build upon the available ecological toxicity data for the chemicals in wastewaters that we project pose the greatest potential risk to terrestrial and aquatic ecosystems and species of concern. In 2016, the Fisheries program is requesting an increase to build upon the 2015 investment.

Activity: Ecosystems
Subactivity: Wildlife Program

2014 Actual: $44.8 million (294 FTE)
2015 Enacted: $45.3 million (289 FTE)
2016 Request: $46.7 million (290 FTE)

Overview

Wildlife and the habitats upon which they depend are an enduring part of the United States' rich natural heritage. They boost the economy directly through hunting, bird watching and other recreational opportunities and contribute to food security, medical research, and genetic diversity. Healthy habitats that support wildlife also provide healthy soils, clean water, carbon storage, and storm mitigation. The Department of the Interior (Interior) has responsibility for the conservation and management of a number of wildlife species through the Endangered Species Act (ESA), the Migratory Bird Treaty Act (MBTA), the Marine Mammal Protection Act (MMPA) and other statutory responsibilities. The USGS Wildlife Program conducts research on migratory birds, terrestrial and marine mammals, amphibians and reptiles, terrestrial plants, threatened and endangered species, wildlife disease, and on wildlife issues resulting from human activities such as energy development. Research spans all functional aspects of the ecosystems that these wildlife species need to survive. This contributes toward a more complete understanding of the Nation's ecosystems and landscapes, helping Federal, tribal, and State managers and policymakers make informed, cost-effective, and balanced decisions of economic, social, ecological, and cultural importance.

The Wildlife Program supports four key activities:

Conservation and Management of Wildlife and Their Habitats
The USGS conducts basic and applied research on factors influencing the distribution, abundance, and condition of wildlife populations and their associated ecosystems. Many activities focus on the development of new information and tools for the management of wildlife on federally managed lands such as national parks, national wildlife refuges, and Bureau of Land Management (BLM) managed lands, and the results of USGS science are transferrable to other public and private landscapes.

Tools and Techniques for Effective, Science-Based Management
The USGS develops tools and methods for wildlife management including modeling alternative scenarios for resource management, incorporation of new and specialized statistical formulas and programs, analysis of large-scale genomic datasets, and identification and prediction of disease outbreaks and spread.

Factors Affecting Conservation of Species of Concern
The USGS provides scientific information in support of management decisions related to species protected under the ESA, MMPA, and similar State laws and regulations, as well as other species in

decline such as amphibians. This information is used by resource managers in listing decisions and other management actions for wildlife species.

Emerging Wildlife Issues
Wildlife resources are being affected in unanticipated ways by multiple stressors such as fragmented habitat, invasive species, disease, and climate change. The USGS provides interdisciplinary science on a constantly changing array of issues to help managers, policymakers, and industry make decisions using landscape or regional approaches to evaluate potential impacts to species or habitats.

Program Performance

Polar Bears – The polar bear was listed as a globally threatened species under the Endangered Species Act (ESA) in 2008. Two of the 19 polar bear populations worldwide occur in the United States, and long-term data from the USGS research program on these populations have provided critical information about response of polar bears to sea ice loss from climate warming. The U.S. Fish and Wildlife Service (FWS), Bureau of Land Management (BLM) and Bureau of Ocean Energy Management (BOEM) rely on USGS for research information about polar bears. Polar bears are nutritionally and culturally important to Alaska Natives and their Inuit neighbors in Canada and Russia; other stakeholders include the State of Alaska, the oil and gas industry, and conservation organizations. In 2014, USGS data on polar bears were used to inform the development of the U.S. Polar Bear Conservation Management Plan to meet ESA and Marine Mammal Protection Act requirements. This plan will also serve as the United States contribution to a global plan being prepared by the five polar bear Range nations (United States, Canada, Russia, Greenland, and Norway), and will lead to the next meeting in September 2015. A model to evaluate and rank threats to polar bears was updated with new information since the listing decision. This analysis confirmed the importance of mitigating greenhouse gas emissions to the long-term persistence of polar bears. The USGS also provided updated information on the status of the southern Beaufort Sea population, documenting population decline by approximately 40 percent in the early 2000s then stabilizing by 2010. Activities in 2015 and 2016 will focus on understanding the significance of increased onshore presence of polar bears in Alaska, which raises concerns for the oil industry and coastal communities, and continuation of studies to understand the effects of declining sea ice on polar bear nutritional ecology, energetics, habitat use, and ultimately, population dynamics.


Polar bear on barrier island, southern Beaufort Sea coast, Alaska. Image courtesy of FWS.

Surveillance of White-Nose Syndrome in Bats – White-nose syndrome (WNS) is still on course to rank among the most destructive wildlife diseases to emerge in recorded history, and it has continued to have

unprecedented effects on populations of hibernating bats in North America. Bats are the primary predators of night-flying insects, and the natural pest-control services they provide are valued at billions of dollars each year to agriculture in the continental United States. In the past seven years, the cold-adapted fungus that causes WNS (*Pseudogymnoascus destructans*) has spread across at least 25 States in the United States and four Canadian provinces, and has continued to cause mortality and population declines in multiple species of hibernating bats. Unfortunately, the exact processes by which the fungus kills bats are not clearly understood. A better understanding of bat hibernation and disease progression under natural conditions is vital to understanding and responding to WNS. However, discovering the details of what hibernating bats do in cold, dark, undisturbed caves and mines during winter has proven extremely difficult. No previous studies have observed hibernating bats in their natural winter habitats continuously over an entire winter season. During the past five years (2010-2014), USGS researchers succeeded in the first effort of this kind and have been watching bats hibernate with near infrared and thermal video surveillance cameras at multiple sites in the Eastern United States. Using a combination of custom-made and off-the-shelf equipment, thousands of hours of unprecedented imagery have been recorded with no disturbance to the bats. During 2014, monitoring of little brown bats (the species most affected by WNS) continued at a cave on National Park Service (NPS) land for the sixth straight winter and analysis of video imagery is well underway. Additional monitoring is planned for 2015 and 2016. This is the only site in the world for which multiple years of long-term winter observations of hibernating bats have been made. These new observations offer an unprecedented glimpse into the hibernation of bats both before and after the arrival of WNS, as well as how the behaviors of bats may change in the wake of WNS and allow some individuals to survive. Watching bats hibernate in the dark using video has tremendous potential for quickly advancing our understanding of how WNS alters bat hibernation behavior and may lead to new methods of managing the disease.

Infrared surveillance video of little brown bats (*Myotis lucifugus*) with white-nose syndrome hibernating in a cave during winter in the southeastern United States. Image courtesy of Paul Cryan, USGS.

Bats and Wind Turbines Don't Have to Mix – Few sources of electrical energy come without an environmental cost and wind turbines are no exception. Certain kinds of bats are dying in unprecedented numbers at wind turbines, impeding wind energy development in many regions. Over the past decade, USGS researchers focused attention on trying to understand the causes of bat susceptibility to turbines so that practical solutions to the problem can be developed. Recent studies by the USGS and its science partners led to the discoveries that bats approach wind turbines in ways that suggest they may be mistaking them for trees, that the most-affected species might migrate in very different patterns than was assumed, and that bats can occur around turbines more frequently than conventional monitoring methods might indicate. These discoveries are the foundation of a new USGS research effort aimed at enhancing

the sensory perception of bats in order to try and dissuade them from approaching wind turbines. A paper describing the continental migration patterns of bats as they relate to wind energy was published by USGS authors in Ecological Applications. Another describing the tree-like behaviors of bats at turbines was published in the Proceedings of the National Academy of Sciences in 2014, and two manuscripts describing research into the perceptual abilities of bats and field trials of a method for altering bat perception are in preparation for submission to high-profile scientific journals in 2015. Building upon this exciting new research, the USGS and its research partners are moving forward with developing and testing a practical device for reducing bat fatalities at wind turbines in 2015 and 2016. USGS research results and approaches for reducing bat fatalities at turbines have the potential to be widely used by a variety of partners and customers across industry, government, and conservation organizations facing the challenge of bat mortality attributable to wind energy development.

Scientists from the USGS and University of Hawaii at Hilo setting up a ruggedized video surveillance system beneath a wind turbine on the Island of Oahu, Hawaii. Image courtesy of Paul Cryan, USGS.

Interactions between Ungulates and the Environment – Big game hunting provides a major revenue source for much of the management efforts conducted by State agencies. Changing climate, land-use, and energy development are likely to have major impacts on grazing ungulates (hoofed mammals) like wild horses, elk, and bighorn sheep. The USGS and its partners are working on a range of projects from the grazing impacts of wild horses, to the transmission of brucellosis (infectious bacteria) from elk to cattle, to the effects of energy development on migrations, to evaluating ways to integrate innovations in the technology industry into monitoring bighorn sheep population abundance and

Elk during winter at a supplemental feeding area in western Wyoming. Image courtesy USGS.

health. Cattle and elk in Wyoming, Idaho, and Montana are increasingly becoming infected with brucellosis. This affects ranchers' ability in those States to sell and trade their livestock at a national and international level in 2014. The USGS has helped to discover why this disease appears to be spreading to new regions and is working toward predicting the future spread in 2015 and beyond. This research will help inform livestock and elk managers about the most effective testing regimes to keep the nation's livestock safe.

Evaluating New Approaches to Monitor Bighorn Sheep Abundance and Health – Bighorn sheep are symbolic of the rugged West, important in native cultures, and highly valued as a game animal. Though still very low in numbers relative to the widespread populations that existed prior to European settlement, conservation efforts have succeeded in maintaining viable populations in North America. In the trans-boundary region of northwestern Montana, Alberta, and the Blackfeet Reservation, USGS researchers are evaluating ways to non-invasively and inexpensively monitor abundance and health of bighorn sheep. Research conducted in 2014 has identified efficient locations to monitor based on limiting resources on the landscape (salt licks and movement corridors) and proposes in 2015 and beyond to integrate novel remote sensing technologies that could allow unique identification of most individuals, which would allow population estimation. The use of non-invasive techniques to monitor bighorn sheep are also being developed and tested in the Intermountain West. Using fecal DNA, bighorn sheep are identified and mark-resight models are used to estimate population size. The technique has been particularly important in Wilderness Areas, where the use of helicopters to count bighorn sheep is limited, and preserving wilderness character is a concern. This work may lead to improved understanding of population fluctuations in game, threatened, and endangered species with horns in the United States and across the world.

These three rams in northwestern Montana have unique horns that can be used for identifying individuals and track bighorn sheep demographics. Image courtesy of Tabitha Graves, USGS.

Research and Assistance for the Bureau of Land Management (BLM) Wild Horse and Burro Program – Management areas for free-roaming horses and burros span 36.7 million hectares across 10 Western States and intersect numerous natural-resource issues of great interest to land-management agencies and other conservation practitioners. These include Greater Sage-Grouse, elk, mule deer, migration corridors of pronghorn and other native ungulates, distribution and spread of invasive plants, and water quality, among others. As part of an ongoing wild horse and burro research program, the USGS is conducting research that includes a focus on two important themes: population estimation and fertility control. Reliable population estimates are critical for wild horse management, as herd size can

double in as little as four to six years. The USGS has been leading research efforts to count wild horses and burros since the 1990s. As part of ongoing work conducted in 2014, the USGS has developed and tested two aerial survey protocols and one non-invasive technique using fecal DNA, and the USGS has plans to test forward looking infrared (FLIR) in 2015. Additional ongoing research planned for 2015 will investigate using contraceptives for population control in wild horses, which has been an ongoing challenge. Two contraceptive agents that have been tested by the USGS hold promise and are being investigated further. The aim of the USGS work on population estimation methods and fertility control is to provide the BLM and other agencies with better tools to help with management of wild horses and burros in the West.

A band of free-roaming horses on a Department of Interior-administered sage steppe-scrub landscape in the West. Image courtesy of USGS/BLM.

Lidar Data Improves Models of Marbled Murrelet and Spotted Owl Habitat – Forest managers in the Pacific Northwest balance the habitat requirements of native wildlife with timber harvest, recreation, and a diverse range of other land use objectives. Protecting habitat for the federally threatened marbled murrelet and northern spotted owl are high priorities, particularly for Federal forest managers within the area of the Northwest Forest Plan. Accurate maps of suitable habitat are particularly important for implementing recovery plans for these threatened species. The USGS has been working to develop tools that help managers better identify critical resources needed by marbled murrelets and northern spotted owls, and facilitate habitat management for these species. Light Detection and Ranging, or lidar, is a remote-sensing tool that can describe both the vertical and horizontal distribution of vegetation, providing a powerful tool for quantifying forest canopy complexity. To test the utility of lidar for forest management, the USGS and collaborators developed a lidar-based nesting habitat model for the federally threatened marbled murrelet in the Oregon Coast Range. The study, published in 2014 in the Wildlife Society Bulletin, found that lidar data more accurately described canopy structure relevant to murrelet nesting ecology and resulted in a more accurate representation of murrelet nesting habitat when compared to traditional methods. The resulting refined model is helping managers more accurately estimate the availability of murrelet nesting habitat in forests. In 2015, USGS scientists will evaluate the use of lidar data for

Northern Spotted owl. Photo Credit: Sue Haig, USGS

development of habitat models for the northern spotted owl and red tree vole, an important prey species for the northern spotted owl.

Understanding California Condor Flight and Potential Risk from Wind Energy Development – The California condor is an iconic symbol of conservation in the United States. In the 1980s, the bird was on the brink of extinction and the last remaining individuals were removed from the wild and placed in zoos for their protection. Through subsequent captive breeding and intensive management programs, California condors have now been returned to the wild in portions of California, Arizona, Mexico, and adjacent areas. Identifying and minimizing the risk posed by potential threats is essential to the condor's continued recovery. The USGS is meeting the urgent need to understand how condor movements and flight behavior may expose them to risk from wind energy development, and how those risks might be avoided or minimized. In 2014, the USGS and its collaborators published a study in Bird Conservation International that evaluated the home range of both wild- and captive-reared California condors, and documented seasonal variation in condor movements that may help conservation planning for this critically endangered species. In 2015-2018, the USGS will use high frequency Global Positioning System-Global System for Mobile Communication (GPS-GSM) telemetry to study how California condor flight behavior, especially altitude, responds to variation in topography and weather. This information can be used to identify conditions that may be preferentially used by condors, and to predict risk to birds from existing and proposed wind turbines.

California condor. Photo credit: Sue Haig, USGS

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Activity: Ecosystems
Subactivity: Environments Program

2014 Actual: $36.2 million (185 FTE)
2015 Enacted: $36.2 million (177 FTE)
2016 Request: $42.8 million (211 FTE)

Overview

The Department of the Interior is responsible for the stewardship of approximately 20 percent of our Nation's lands. Interior is the largest supplier of water in the 17 Western States, the Nation's second largest producer of hydroelectric power, oversees 27 percent of oil and 15 percent of natural gas produced domestically, and manages conventional and renewable energy development on 41 million acres within the Outer Continental Shelf. Additionally, Interior upholds Federal trust responsibilities to Indian tribes and Alaska Natives; is responsible for migratory wildlife and threatened and endangered species conservation; and works in partnership for conservation activities on non-Federal lands and priority ecosystems across the United States.

"The South Florida Water Management District is Florida's lead agency in Everglades restoration, one of the largest environmental restoration efforts in the world. Science-based planning, project design and testing are a critical part of this work. The USGS, with its scientific expertise in modeling ecosystem processes, has been an integral partner in these restoration efforts."

Blake Guillory, P.E.
Executive Director
South Florida Water Management District

The Environments Program assists in meeting Interior stewardship responsibilities across these large landscapes by providing the science to support informed decisionmaking and adaptive management for sustainable resource use and conservation. The USGS conducts research to assess, understand, model, and forecast the impacts of natural and human-induced changes to our ecosystems and natural resources, and how those changes may be mitigated. Informed forecasting of landscape structure, function, composition, and condition requires an understanding of the factors that control, constrain, and regulate ecosystem dynamics. USGS science is focused on understanding these driving factors using ecological research, long-term field studies and ecosystem modeling, and applying remote sensing and geospatial technologies as needed. Additionally, the USGS can evaluate trade-offs among alternative strategies for land management, land use, mitigation, conservation, and restoration to benefit ecosystems, landscapes, infrastructure, and economies.

The Environments Program integrates its ecological science with research from other mission areas and universities, government agencies, and non-governmental organizations to produce research and deliver scientific findings that are responsive, integrated, and applied. The products of USGS's integrated research represent science-based alternatives that can reconcile and accommodate both the conservation and use of natural resources; problems faced by policymakers, resource managers, and community planners.

For example, USGS scientists have expertise in coastal ecology and wetland science which enables them to understand the interactions of coastal marshes and forests with stressors like storms and oil spills against the backdrop of longer-term impacts such as sediment deposition and sea-level changes. A group of these scientists was mobilized, with the support of a supplemental appropriation, to study the impacts of Hurricane Sandy, which made landfall in North America on October 29, 2012. Since 2013, the USGS has continued to support the Department of the Interior to manage its coastal lands after Hurricane Sandy. The USGS is studying how the hurricane impacted wetlands, forests, and populations of aquatic species along the coast such as fish, turtles, and birds. The USGS will be combining these data with information on coastal physical processes to construct maps of the impacts and develop models of how these habitats may respond to future storms. The models can be used to assess the vulnerability of these coastal habitats and identify the location of more resilient habitats to inform decisions about where to prioritize restoration.

> *"The water-quality report produced by University of Maryland and USGS shows that long-term efforts to reduce pollution are working, but we need to remain patient and diligent in making sure we are putting the right practices in place at the right locations in Chesapeake Bay watershed. Science has and will continue to play a critical role informing us about what is working and what still needs to be done."*
>
> Donald Boesch
> President, University of Maryland Center for Environmental Science

Program Performance

Landscape Science – The USGS conducts broad-scale research and monitoring in some of the large iconic landscapes of the Nation including the Chesapeake Bay, the Everglades, San Francisco Bay, the Great Lakes, and the Great Basin Desert. These projects share similar features because they focus on local species and processes with a goal to determine how they operate in and between multiple ecosystems over large landscapes over time. The USGS contributes science to support large-scale planning efforts, such as the latest revision of the Chesapeake Bay Plan in 2014. The USGS's focus on important Interior decisions remains a primary factor in decisions about what species and habitats to study.

Everglades – The Everglades is valued for its world-class ecological resources. However, a century of water management has decreased the amount and quality of water entering what was formerly an ecosystem with rich biodiversity and unique ecological characteristics. The USGS has contributed substantially to the science underlying the congressionally authorized restoration plan for the Everglades, including contributing to a better understanding of the effects of water flow on maintenance and restoration of the unique landscape. In November 2013, eight years of planning culminated in the opening of a new water control structure, which allows flow between two parts of the Everglades system that have been separated for decades by levees and canals. This large-scale field test was designed to address uncertainties in how to decompartmentalize this system and enhance water flow. The USGS is working on every aspect of the project including collecting water flow data, installing velocity sensors by scuba, and conducting research on downstream particle transport. The results of this field test are essential to the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District; the restoration project co-sponsors who need these data to update their design of the

restoration projects. In 2015 and 2016, the USGS is working with the FWS to improve the design for monitoring hard-to-detect species such as the rare Cape Sable Seaside Sparrow and the cryptic invasive Burmese python.

San Francisco Bay Wetland Restoration – Just east of Silicon Valley, the South San Francisco Bay Salt Pond Restoration Project is the largest tidal wetland restoration project on the West Coast. When complete, the project will have restored 15,100 acres of industrial salt ponds into a rich mosaic of tidal wetlands and managed ponds that provide wildlife habitat, outdoor recreation sites, and natural flood buffers. The USGS is the lead science partner for the restoration project. In 2014, the USGS researched how effective restored sites were in providing crucial habitat necessary for the survival of wintering migratory waterfowl and shorebirds in the Pacific Flyway of North America. The USGS studies also evaluated how well restoration of habitat for breeding water birds accommodated recreational opportunities for the public. In 2015 and 2016, the USGS will continue to work with resource managers to evaluate how well wetland management strategies increase the use of restored sites by water birds in order to inform adaptively managed restoration construction in progress.

Chesapeake Bay – The Department of the Interior has a leadership role for seven of the 10 goals in the 2014 Chesapeake Bay Agreement, which guides the restoration and conservation of the Nation's largest estuary for the next decade. USGS research, which has evolved to address the new ecosystem management issues, will include: (1) investigating the effects of land and climate change on freshwater fish populations and habitats; (2) identifying the sources and effects of chemicals causing intersex conditions in fish and wildlife; (3) modeling the carrying capacity of wetlands near six U.S. Fish and Wildlife Service (FWS) Refuges in the Bay to support Black Duck and waterfowl populations; (4) predicting effects of changes in land use and climate to inform land conservation efforts led by the National Park Service (NPS) and climate adaptation planners; and (5) monitoring water quality in response to management activities to reduce nutrient and sediment loads, and explaining findings to stakeholders. The water quality results are being used by the six States in the watershed and the U.S. Environmental Protection Agency (EPA) to revise plans to meet the Chesapeake Bay Total Maximum Daily Load—the Nation's largest water-quality improvement effort. Selected products planned for 2015 include a report of climate change effects on stream temperatures, and summaries of information on the occurrence of intersex conditions in fish and wildlife species. In 2016, anticipated products include a report on water-quality trends and an improved land-change analysis of the watershed.

Sage Steppe Management Evaluations and Decision Support to Benefit Greater Sage-Grouse – The Bureau of Land Management (BLM) applies numerous management treatments to eliminate or reduce vegetative species not representative of ideal greater sage-grouse habitat, and conducts emergency stabilization and rehabilitation of areas lost to wildfire. The USGS has researched the efficacy of sage steppe ecosystem rehabilitation to inform these management decisions. Three publications released in 2014 examined the effectiveness of treatments to: (1) restore sage steppe and create habitat for sage-grouse; (2) enhance native plant cover and reduce nonnative plants; and (3) restore sage steppe where piñon and juniper have been removed. Additionally, the USGS and other Federal and State agencies worked cooperatively to produce a

decision-support tool that combines the ecological requirements of sage-grouse with factors that contribute to a productive sage steppe ecosystem to help land managers determine appropriate strategies for restoring or maintaining sage-grouse habitats. This decision-support tool is being incorporated by the BLM into their draft management plans. Efforts in 2015 and beyond will examine the factors that contribute to the establishment of sage steppe across the range of the sage-grouse, and whether the current seeding and planting sage steppe ultimately creates high quality sage-grouse habitat.

Adult male Greater sage-grouse strutting on a lek in the Great Basin Desert.

Great Lakes – The USGS began sampling western Lake Erie in 2013 to determine the mechanisms causing harmful algal blooms. Toxins from the 2014 blooms caused a shutdown of the Toledo, OH, water supply for three days, leaving 500,000 residents without drinking water. Data collected before, during, and after the event is determining what triggers the blooms and helping managers devise remediation strategies to reduce their frequency and severity. The USGS participated in Lake Erie's year of intensive sampling in 2014, with an emphasis on determining fish responses to a large hypoxic zone that has developed frequently in recent years. Intensive sampling efforts are rotated annually among the Great Lakes where USGS' large vessel figures prominently in the sampling. In 2015, intensive sampling will shift to Lake Michigan where food web shifts attributed to invading Dreissenid mussels have substantially reduced fish production. The USGS has been the science lead for siting constructed fish-spawning reefs in rivers feeding the Great Lakes and evaluating

Detroit River emptying (A) into harmful algal bloom (B) in Western Lake Erie, 2013. Effects of nutrients from the Detroit Metropolitan Area on overall bloom are poorly understood.

their contribution to the restoration of iconic species such as walleye and lake sturgeon. The spawning reefs are an important contribution to delisting of legacy Areas of Concern, a centerpiece of the Great Lakes Restoration Initiative. In 2016, the USGS will expand the scale of its research on the relationships between the nutrients and algae to include clarifying (1) the extent to which the Detroit River is contributing to the algal blooms in Western Lake Erie, and (2) the dynamics of microbial communities within the algal mats. USGS research has been building toward a regional synthesis that can be translated into management alternatives for regional lake managers.

Fire Ecology – The USGS has led multiple projects across the country to increase understanding of wildfire ecology and management in landscapes exposed to stressors due to changing land use, invasive species, and climate changes. For example, the USGS conducted research across the Western United States to evaluate how effective fuel reduction strategies are at decreasing the risk of wildfire. At the request of the NPS, the USGS coordinated an interagency science advisory team to study the 2013 Rim Fire, the third largest wildfire in California history. In 2014, the USGS participated in the three-year study funded by the Joint Fire Science Program to understand the historic trends leading to the Rim Fire and to identify possible future scenarios, a priority management question for Yosemite National Park. Additionally, the USGS is concluding a study on how past fire management practices have affected the amount of carbon storage in ecosystems of Yosemite National Park and Sequoia Kings Canyon National Park. In 2014, the USGS reported on effectiveness of various habitat recovery treatments following wildfire in sage steppe ecosystems. In 2015 and 2016, the USGS will put emphasis on studying wildfire impacts in arid lands, especially sage steppe habitats invaded by exotic cheatgrass, and chaparral ecosystems. The sage steppe work is important for helping Interior bureaus evaluate management and restoration scenarios as they contribute to the information the FWS will use to support their 2015 decision on whether to list the greater sage-grouse. The USGS will also continue to study the effectiveness of fuel reduction strategies.


Fire crews working on a fire on public lands.

Southwest Vegetation Response to Droughts – The Southwestern United States is expected to warm faster than many other parts of the country and receive less precipitation than average, further reducing soil moisture in an already water-limited environment. This is also a region experiencing increased demands for energy production and transmission. To increase the accuracy of predictions about plant responses to climate change, it is essential to determine the long-term dynamics of plant species associated with past climate conditions. In 2014, the USGS developed a model that uses physical

attributes (e.g., plant life history, soil characteristics) to predict how increases in aridity will affect vegetation on lands managed by Interior throughout the Southwestern United States. To test the model, the USGS synthesized 50 years of repeated measurements from large permanent vegetation plots in the Mojave Desert. Despite the longevity of many plants in desert ecosystems, results revealed that long-term changes in the timing and amount of precipitation coupled with increases in temperature are shifting the cover of woody and herbaceous species. USGS models predicted possible ecosystem changes, which can help Interior bureaus, make short-term management decisions and conduct long-term planning in the face of projected climate change. Stakeholders on the project include the NPS, BLM, FWS, and Department of Defense (DOD). In 2015 and 2016, the USGS plans to: (1) increase the understanding of how land use practices interact with climate to affect the state of vegetation; (2) simulate shifts in plant species assemblages and distributions; and (3) incorporate data on the timing of development and maturation of plants (i.e., phenology) into our understanding of the vulnerability of plants to drought and climate change.

Eastern Pacific Marine Species Research – To inform marine resource planning throughout the eastern Pacific, the Bureau of Ocean Energy Management (BOEM) requires information on the distributions, abundance, and habitat use of marine birds and mammals; especially those inhabiting the U.S. Eastern Pacific continental shelf. Specifically, these studies identify areas of high use by these species. The USGS recently led the first comprehensive, large-scale, multi-seasonal aerial survey of the northern California Current System since historic surveys were completed two decades ago. Surveys were conducted along 32 transects from Fort Bragg, CA, to Grays Harbor, WA. The surveys recorded thousands of individuals from 54 seabird species and 21 whale or seal species. In 2014, the USGS produced species-specific maps and a geospatial database for BOEM managers. In 2015, the USGS is comparing these results to past surveys and integrating aerial survey data with remote sensing and historic satellite telemetry data to identify critical hotspots for marine mammals and seabirds. The USGS is also evaluating at-sea movements, population biology, and the conservation status of seabird species to generate a comprehensive Vulnerability Index to quantify risks of colliding with or displacing these individuals. In 2016, the USGS and partners will augment existing survey and telemetry data with focused studies tracking seabirds off Oregon to inform planning for alternative energy development at sea.

Activity: Ecosystems
Subactivity: Invasive Species

2014 Actual: $13.1 million (63 FTE)
2015 Enacted: $16.8 million (73 FTE)
2016 Request: $19.3 million (77 FTE)

Overview

Nonindigenous invasive plants and animals cause significant economic losses and diminishing opportunities for beneficial uses of valued resources such as forests, croplands, rangelands, and aquatic resources. Costly effects include clogging of water facilities (e.g., quagga and zebra mussels) and waterways (e.g., hydrilla and giant salvinia), wildlife and human disease transmission (e.g., West Nile virus and monkeypox), threats to commercial, native, and farmed fisheries (e.g., Asian carps, snakehead fish, whirling disease, and hemorrhagic septicemia), and increased fire vulnerability and adverse effects for ranchers and farmers (e.g., leafy spurge, cheatgrass, brome, and buffelgrass). In addition, invasive species have been identified as contributing factors in the listing of 40 percent of all threatened and endangered species in the United States and remain a primary concern for natural resource managers. It is estimated that fighting the economic, ecological and health threats posed by over 6,500 invaders (*http://www.nature.nps.gov/biology/invasivespecies/)* costs over $137 billion in damages annually to the U.S. economy. Increased global travel and trade continue to provide additional pathways for both intentional and unintentional introductions of invasive species.

The USGS works on all significant groups of invasive organisms in terrestrial and aquatic ecosystems throughout the United States. USGS scientists partner with State and Federal agencies, tribes, agriculture, natural resource managers, and the private sector to help solve problems posed by invasive species. The USGS joins Federal efforts to combat invasive species by providing information on early detection and assessment of newly established invaders; monitoring invading populations; improving understanding of the ecology of invaders and factors in resistance of habitats to invasion; developing and testing prevention and management and control alternatives, stressing integrated control management approaches where appropriate; and assessing approaches for restoring disturbed habitats after control. USGS science also plays a key role in implementing the National Invasive Species Management Plan, developed by the National Invasive Species Council, as called for in Presidential Executive Order 13112 on invasive species. The Interior bureaus work in partnership with other Federal agencies, State, local, and tribal governments, and private sources to conduct activities related to prevention, early detection and rapid response, control and management, restoration, and organizational collaboration.

Program Performance

Prevention, Early Detection, and Rapid Assessment
USGS research focuses on developing and enhancing capabilities to forecast and predict invasive species establishment and spread. Early detection helps resource managers identify and report new invasive

species, especially for cryptic species and those in very low abundance, to better assess risks to natural areas.

Modeling and Forecasting – The USGS assists resource managers and other decisionmakers by developing and testing spatial models, maps, and decision support tools. These tools can be used to target monitoring efforts, predict potential ranges, simulate application of management alternatives, and predict effects of invasive species. In 2014, the USGS completed several studies to improve the ability to predict the outcome and impact of future invasions. For example, the USGS found that hybrid tamarisk and Africanized honeybees (hybrids of the original invading species with a related species non-native to the United States) had larger predicted suitable habitat ranges than non-hybrids, meaning that risk maps of harmful invasive species, hybrids, and genotypes may help in protecting native species and ecosystems from invaders. In 2014, the USGS published a number of studies predicting potential ranges of invasive species including a marine amphipod, Asian tiger shrimp, American bullfrogs, and lionfish as well as a study identifying suitable habitat for common reed (*Phragmites australis*) around the Great Lakes. Also in 2014, the USGS hosted two training workshops on the use of "Software for Assisted Habitat Modeling" (SAHM), which was released last year. SAHM helps researchers and managers explore and maintain records of multiple parameters and different iterations of habitat modeling and develop meaningful interpretation of results. In 2015, the USGS will continue studies examining the impacts of fire and invasive grasses on bighorn sheep and pygmy rabbits, and will model potential ranges of several aquatic species including the plant Elodea in Alaska. In 2016, several studies are planned involving the effects of climate change on the potential distribution of invasive species such as nutria, cheatgrass, and the native but very damaging pine beetle in the Rocky Mountains.

Early Detection of Invasive Species – Tracking the establishment and spread of existing and new invasive species is critical to effectively manage invasive species. In addition to standard means of monitoring, the USGS is developing new tools, particularly molecular techniques, to assist in the early detection of invasive species. In 2014, the USGS worked to develop multi-species environmental DNA (eDNA) probes for Burmese pythons and their prey species, anacondas, New Zealand mud snails, northern pike, Eurasian watermilfoil, Asian carp, and others. These probes will allow resource managers to collect water samples for molecular analysis and determine whether targeted species are present in an area. In 2014, the USGS validated new genetic markers for bighead and silver carp that are now being used by the U.S. Fish and Wildlife Service (FWS) for Asian carp monitoring, sampled the Upper Mississippi River along a gradient from well-established population to above the presumed leading invasion edge, and completed studies to connect eDNA with spawning activity and fish movement. This will continue in 2015. Also in 2015, other molecular methods such as metabolites and pheromones will be evaluated as complimentary molecular surveillance tools. By the end of 2015, the USGS, working with industry, plan to deliver a portable device to detect Asian carp DNA. In 2016, the USGS will continue to improve and remove uncertainties regarding the use of molecular detection tools for invasive species.

Nonindigenous Aquatic Species Database – The online USGS Nonindigenous Aquatic Species (NAS) database (http://nas.er.usgs.gov) continues to grow. The NAS program monitors, analyzes, and records sightings of non-native aquatic species throughout the United States to help fill information gaps on introduction pathways, geographic distribution, ecology, and impacts of NAS. The database now contains over 173,000 records of approximately 1,000 aquatic species occurring outside of their native range. This information is used widely for a variety of purposes including risk assessments of U.S. Army Corps of Engineers' (USACE) water resource management actions, invasive species monitoring design, and predictive modeling of future invasions. Over 880 resource managers, scientists, and concerned members of the public have signed up for automated alerts on newly sighted species in their region or community. In 2014, the Web site typically received more than 150,000 users per month, and nearly 3,000 of the network domains hosting these users are from State and Federal agencies, local governments, universities, and non-governmental organizations. The USGS also works directly with collaborating agencies such as National Oceanic and Atmospheric Administration (NOAA) and the Smithsonian Institution to offer customized applications that allow managers to focus more closely on a specific region or species. These applications have recently been developed for the Great Lakes and Columbia River regions in support of monitoring and management activities in these important waterways. Throughout 2014 and 2015, reliance of partners on the NAS program continues to grow. For example, aquatic invasive species management plans submitted to the Aquatic Nuisance Species Task Force must now include submitting occurrence data to the NAS database, and the FWS has discontinued use of a national phone number to report aquatic invasive species in lieu of the 'report a species' option on the NAS Web site. In 2014, and at the request of the FWS, the USGS designed and built an early detection data repository for Asian Carp monitoring efforts to enhance partner monitoring efforts in the Great Lakes area. In 2015 and beyond, NAS scientists will lead new investigations for the FWS intended to provide the scientific basis for listing potentially injurious species under the Lacey Act. An upcoming launch of a new Web-based application will allow users in other agencies to graphically integrate NAS data directly into their mapping programs. This Web-based application is expected to be released in 2015 but may take until 2016.

Current distribution of silver carp, indicating where it is established (red dots) and observed (green dots) as an example of distribution maps available from at USGS Nonindigenous Aquatic Species database.

Effects and Risks Posed by Invasive Species

The USGS provides methods and information to assess the effects of invasive species to native species and ecosystems and human health. Understanding life history and environmental requirements and

tolerances of targeted invasive species is critical to developing and allocating control, management, and restoration options.

Biology, Ecology and Population Dynamics of Invasive Species – The USGS conducts research on the biology of many species including Burmese pythons, nutria, Asian carp, buffelgrass, brome, cheatgrass, tamarisk, leafy spurge, snakehead fish, brown tree snakes, zebra and quagga mussels, northern pike, Asian swamp eels, American bullfrogs, and feral pigs to provide the information needed by management agencies. For example, in 2014, a team of USGS scientists co-organized a workshop with the National Park Service (NPS) and the FWS in south Florida on the science and management of large constrictor snakes including Burmese pythons to generate cross-agency management recommendations. To assist FWS and NPS managers move forward with those recommendations, an interagency structured decisionmaking workshop led by the USGS was held in 2014 with scientists and managers. Also in 2014, the USGS completed research on the movement and hibernation behavior of invasive Argentine tegus in Florida using radiotelemetry and automated cameras. Tegus are large omnivorous lizards introduced to Florida via the pet trade, and they pose significant risks as nest predators of sea turtles, crocodilians, and ground-nesting birds. These studies provided information that will help resource managers understand when and where to deploy traps and other tools to control tegu populations. In 2015 and beyond, the USGS will continue to document the distribution and study the life histories and ecology of invasive reptiles in south Florida to better determine important population parameters, identify life stages vulnerable to control, and develop control techniques. This, and other information, will help to inform management and control options.

Burmese python taken from Everglades National Park in Florida.

Control and Management of Invasive Species

USGS research improves existing invasive species control methods, and develops and tests new chemical, physical, molecular, and biological methods of control, stressing integrated control strategies where applicable. These tools permit managers to understand and minimize environmental impacts of invasive species at landscape, regional, and local scales. The USGS has ongoing research to develop and test control methods for a wide variety of invasive species, including Asian carp, brown treesnakes, Burmese pythons and other invasive reptiles, sea lamprey, zebra and quagga mussels, Chinese mystery snails, lake trout, American bullfrogs, among others.

Asian Carp Containment and Control – The USGS is developing options to control Asian carp by chemical, physical, and biological methods. In 2014, the USGS produced batches of microparticles of varying content of fish toxicants, tested those batches with favorable characteristics in tanks with several fish species, and found that those microparticles killed only bighead and silver carps and paddlefish. Work in 2015 will look to reduce effects on paddlefish and test microparticles in ponds with mixed fish species and in the field. In 2014, the USGS began evaluating the use of carbon dioxide to contain Asian carp. In 2015, this technology will be tested in the field. Also in 2014, the USGS used static and mobile acoustic surveys to evaluate an integrated pest management (IPM) approach to contain and remove Asian carp that integrated algal feeding attractants, water gun barriers, and commercial fishing in a backwater of the Illinois River. This research included a demonstration component attended by State and Federal partners. Research will continue in 2015 to evaluate the potential of barriers and integrated controls to prevent Asian carp from moving into critical habitat. The USGS communicated progress on Asian carp research through a webinar on current research, release of a podcast on the 2013 IPM demonstration (*https://www.youtube.com/watch?v=nN8CC3Jax1k*), and a Web site on USGS Asian carp products (http://cida.usgs.gov/glri/index.jsp#/Browse/fais). In 2015 and beyond, the USGS will reach out to additional stakeholders, increase webinars and videos, and provide training as appropriate to implement new technologies.

USGS scientists demonstrating use of water guns to contain Asian carp for partners in a backwater of the Illinois River.

Invasive Species in Hawaii and the Pacific – Invasive species often pose the primary threat to biodiversity in the Pacific. USGS research focuses on the ecology, reducing impacts, and controlling highly invasive plants (e.g., miconia, faya tree, strawberry guava, Kahili ginger), animals (e.g., mouflon, rats, feral pigs, Argentine ant, invasive wasps), and wildlife disease organisms. The USGS was a partner in a study completed in 2014 that tested and recommended control baits for three species of invasive ants on Rose Atoll contributing to the imperilment of a flowering tree. Also in 2014, the USGS completed research that assessed the invisibility of invasive plants in Hawaii. Knowing the invisibility of species allowed researchers to delineate areas of known and potential range given current and future climate scenarios. This work can help prioritize ecosystem and species management actions by identifying the subset of highly invasive and detrimental plants on which to focus control. In 2014, the USGS conducted research to understand and mitigate threats posed by brown treesnakes to the endangered Mariana swiftlet, a small cave-dwelling bird only found on DOD lands on Guam. In 2015 and beyond, the USGS

will continue to better understand aspects of invasion to help managers focus control efforts in Hawaii and develop and continue research in Guam to improve detection tools such as eDNA, monitoring and search strategies, improve control methods, and develop models to assist managers to optimally trade-off effort invested in costly control and snake suppression.

Sea Lamprey and Beyond – The USGS has been conducting research to inform, refine, and improve the Integrated Sea Lamprey Control Program, which is administered by the Great Lakes Fishery Commission (GLFC) for over 60 years. As part of the funding commitment from the USGS, research is being broadened to encourage research on other invasive species and on national fisheries issues such as pheromones and fish passage. New research includes developing tools to selectively pass valued species (American eel, walleye, steelhead, sturgeon, etc.) and selectively remove invasive species by integrating multiple stimuli that induce species-specific responses (such as Asian carp). In 2015, this conceptual model will be tested in a management-scale demonstration project to guide adult sea lampreys to a trap using an electric lead covering 75 percent of the stream width, improve sea lamprey removal efficiency by baiting the trap with a species-specific sex pheromones, block sea lamprey from passing upstream through the portion of the channel not electrified with a species-specific sea lamprey repellent, and guide valued fishes to the portion of the channel not electrified using a second electric lead of lower voltage around an electric sea lamprey control barrier electricity.

Restoration of Invaded Habitats

The USGS develops strategies and techniques to understand and facilitate restoration of native species and habitats affected by invasive species. This is critical because control without restoration can leave the ecosystem vulnerable to subsequent reinvasion by the same or additional invasive species.

Weeds in the West – The USGS conducts multi-scale, integrated assessments to map infestations and accurately monitor the spread of invasive plants in Western forests and arid rangelands; predicts areas most vulnerable to invasive species; assesses the effects of management practices and natural disturbances on invasive species; evaluates how invasive grasses alter the frequency and intensity of wild fires; and improves methods to restore public rangelands affected by weed invasions. The USGS is evaluating techniques to control populations of harmful weeds (e.g., cheatgrass, Sahara mustard, buffelgrass, brome) while maintaining or increasing the abundance and diversity of native annual plants. Non-native cheatgrass is widely distributed in arid lands of the Western United States where its presence affects native plants, nutrient cycles, and the frequency of wildfires. For example, in 2014, the USGS assessed methods to prevent the re-establishment of plants after prescribed burns, determined the importance of moss to improving invasion resistance to cheatgrass, and assessed native plant recovery on an island after the removal of invasive fennel. In 2015 and beyond, the USGS will continue to work with partners to improve ecosystem resistance to invasion and restore ecosystems after controls are applied.

Invasive Riparian Plant Control and Restoration – Researchers debate the extent to which tamarisk and other riparian invasive species such as Russian olive and Siberian elm have had negative effects on waterways in the arid Southwest, but it is clear that they can alter habitat quality for wildlife, water use by floodplain vegetation, and the frequency and intensity of

wildfires. The USGS is addressing some of the most compelling research questions related to these and other non-native plant species that occur in riparian ecosystems in the Western United States. For example, in 2014 the USGS completed a study that demonstrated synergistic interactions between tamarisk leaf beetle herbivory and prescribed burns in controlling tamarisk and completed another study that investigated the importance of hybridization among species of tamarisk species and resistance to deforestation by the tamarisk leaf beetle. Results of these studies and others can help resource managers to allocate resources to maximize control efforts. Similar research continues into 2015 and beyond.

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Activity: Ecosystems
Subactivity: Cooperative Research Units

2014 Actual: $17.4 million (152 FTE)
2015 Enacted: $17.4 million (152 FTE)
2016 Request: $20.0 million (161 FTE)

Overview

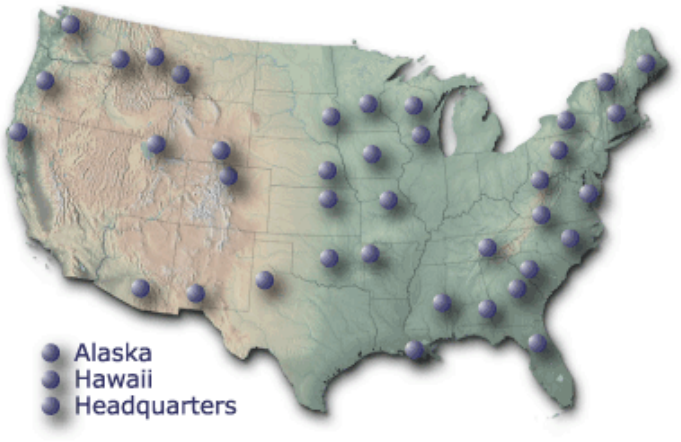
The Cooperative Research Unit (CRU) program is a unique and cooperative relationship among the USGS, State fish and wildlife agencies, host universities, and the Wildlife Management Institute. The FWS is a formal cooperator in most of the individual Units. Since 1935, this cooperative relationship has provided a strong connection between the USGS, State and Federal management agencies, and the national university community. Individual resources of each cooperator are leveraged to deliver program outcomes that far exceed what any one cooperator could achieve alone.

"The VPI & SU Coop Unit has for decades been a major partner in supporting the Virginia Department of Game and Inland Fisheries in wildlife resource management and research. The cooperative partnership has placed Virginia in a leadership role in multiple areas from endangered mussel species propagation and restoration to big game management."

Bob Duncan
Executive Director
Virginia Department of
Game and Inland Fisheries

The goals of the CRU program are to sustain and maintain—

- A cost-effective, national network of Federal, State, and university partnerships pursuant to the Cooperative Research Units Act of 1960, with a legislated mission of research, education, and technical assistance focused on fish, wildlife, ecology, and natural resources.
- A customer-oriented network of expertise for research, teaching, and technical assistance that is responsive to information needs of State and Federal resource agencies.
- Science capabilities responsive to resource management needs of Interior bureaus.
- A premier program for graduate education and training of future natural resources professionals having skills to serve the broad natural resources management community successfully.



Locations of the Cooperative Research Units

The CRU program is comprised of 40 CRUs located at universities in 38 States, with a headquarters office in Reston, VA. The program is designed to leverage cooperative partnerships with Federal and State agencies to address mutual needs of all partners in a cost effective manner. The USGS stations Federal scientists at universities to help identify and respond to natural resource information needs through pooling of resources among agencies, participate in advanced scientific training of university graduate students, and provide Federal and other natural resource managers' access to university expertise and facilities.

Federal support of the CRUs is multiplied by State and university cooperator contributions of expertise, equipment, facilities, and project funding, thereby enhancing the program's cost-effectiveness. Through university affiliations, CRU scientists train future natural resource professionals and provide opportunities through graduate education to diversify the Federal workforce.

Each CRU is directed by a Coordinating Committee comprised of Federal, State, university, and Wildlife Management Institute representatives. Each Coordinating Committee establishes goals and expectations for its unit within the program's mission of research, education, and technical assistance. The mix of priorities is established locally and is updated annually based on needs of cooperators and available funding. Program accountability measures, performance standards, and oversight of Federal scientists are used to ensure research and the resulting scientific information products support the goals of the USGS and Interior.

University and State agency contributions to the program remain strong, as does Federal, State, and local government reimbursable funding for research and technical assistance. Cooperator-focused satisfaction surveys continue to indicate a satisfaction rate of 95 percent or greater with CRU program execution. The program's appropriated dollars continue to be matched by State, university, Federal, and other entities' contributions at a ratio of three matching dollars to each appropriated dollar.

Program Performance

To meet future natural resource management challenges, the program continually invests in new approaches to help State and Federal cooperators implement science-based decision making more effectively. These approaches will further provide a framework for cooperators to work together across State and regional boundaries and address large-scale, trans-boundary issues. The CRU program is recognized by Interior as the primary source of technical expertise on structured decision making and adaptive management and is actively working with Interior bureaus to bring science to bear on regulatory and management decisions. Interior bureaus are faced with significant resource decisions and complexities in the face of unpredictable effects of climate change. Currently, expert knowledge and application of structured decisionmaking and adaptive management is limited and does not meet management's need for this expertise.

To meet this need, the CRU continues its partnership with Oregon State University to develop and deliver an online, graduate level course in structured decisionmaking and adaptive management. To date, 18 graduate students, competitively selected from across the Nation, have completed this course and have incorporated learned principles into their research projects. This online course has expanded the

opportunity of CRU graduate students to learn systematic and innovative approaches to science-based natural resources management. As these graduates populate the workforce of our State and Federal partners, an increased capacity will be realized across all agencies, which will foster collaboration and promote rapid adoption of the overall approach. Since many CRU graduates find employment within the Interior, these efforts will ensure the Department is better positioned to achieve its strategic goal of enhancing science-based natural resources decision making, and supports the Interior's Strategic Plan goal of building a 21st century workforce.

To meet youth and diversity goals, the CRU is engaged in the Doris Duke Conservation Scholars Program (*http://programs.ifas.ufl.edu/ddcsp*), which is a new partnership between five CRU host universities (University of Florida, Cornell University, University of Arizona, University of Idaho, and North Carolina State University). The program provides undergraduate students from groups under-represented in the conservation workforce with hands-on experience. Students are mentored by CRU supported graduate students and research scientists. Students attend leadership training programs, work with scientists and graduate students on selected research projects, and complete paid internships with local, State, Federal, and tribal agencies or Nongovernmental organizations (NGOs). During summer 2014, the first cohort of participating scholars was fully engaged in experiential learning activities provided through research of CRU scientists and directed in the field by the graduate student mentors. Other programs under development in partnership with the U.S. Fish and Wildlife Service (FWS) will support graduate and undergraduate students conducting research on National Wildlife Refuges as a means to develop and recruit Federal scientists and natural resource managers. Students address contemporary research topics including the application of science and analytical tools for decisionmaking, energy development, fire ecology, ecosystem sustainability, threatened & endangered species, invasive species, and water quality and use.

Plans to develop new ways of working across State and regional boundaries have been incorporated as a key goal of the decision support initiative. In fact, CRU cooperators fully support broad-scale research projects aimed at understanding mechanisms affecting species and habitats at unprecedented scales. For example, trans-boundary collaboration is currently being used to address concurrent overlapping issues, including climate change, the conservation challenge currently presenting the greatest uncertainty to natural resource managers. CRU Units in Wyoming, Utah, and Montana, in conjunction with multiple Western States, are coordinating an assessment of elk data across their geographic range to identify options for managing elk herds in ways not possible from a single-State perspective. This type of trans-boundary approach to wildlife research is an important precursor to the multitude of landscape-level wildlife-management research issues that will arise as climate changes. A similar trans-boundary, multi-agency approach to address the effects of climate change on moose is currently being explored. CRU's extensive work in climate change research directly supports and aligns with Interior and the USGS strategic science vision that in many cases will require a trans-boundary approach, an approach CRUs are uniquely positioned to facilitate.

Through 2014, CRU scientists used the approaches as described to support National and Interior interests in balanced energy development, climate change, and threatened fish and wildlife conservation. The continuing effort to strengthen science capacity in the CRU will ultimately lead to enhancement and

expansion of graduate education and science training as mandated in the Cooperative Units Act, and thereby contribute to the science expertise and capacity needed to meet future natural resource challenges.

The CRU program has more than 800 active projects at the start of 2014. Many of these projects exemplify how CRU scientists are bringing decision support tools to Interior agencies for making important decisions on managing our Nation's natural resources. Consistent with the program initiatives highlighted above, many of the projects are using structured decision making or adaptive management to address landscape level issues associated with climate change and energy development. CRU scientists at 23 Units currently have 52 active research projects (48 are in support of Interior) to better understand and predict the potential effects of climate change on the future availability of habitat and resulting distribution of species in the future. Similarly, five Units have nine projects related to understanding the impact of energy projects on the distribution and life history of a variety of ecologically or economically important species. These studies are not only critical for understanding the biological and environmental processes but also for informing decisions that integrate the underlying biology with societal needs and values.

Examples of ongoing research projects that highlight how CRU scientists are helping our State and Federal partners make science-based management decisions include:

Conservation of Lesser Prairie Chickens – CRU scientists in Texas, Kansas, and New Mexico are working on Lesser Prairie Chicken (LPC) life history, spatial habitat dynamics, and population characteristics. Unit research will be used to establish State-level conservation plans for LPCs, which are vital for FWS management of the species at a regional scale. Highly innovative approaches such as satellite tracking are being used to gain information at formerly unprecedented spatial scales across the entire range of the LPC. This broad-scale understanding is vital for developing conservation and mitigation measures in the face of climate change and associated issues, such as drought, land use, fire, and changes in structure of native prairie habitats. Scientific resources at the Units are highly leveraged with researchers at multiple universities and Unit scientists have established strong collaborations with non-governmental organizations and private landowners who have and will continue to play a vital role in both LPC research and implementation of science-based conservation and restoration measures.

Whooping Crane Introduction in Louisiana – Based on evaluations by the Louisiana CRU, the White Lake Wetlands Conservation Area in Louisiana was selected for establishment of a resident Whooping Crane population. Multiple releases of cranes from the Patuxent Wildlife Research Center began in 2010 and habitat use, movements, and survival are being assessed by Unit scientists to assist the Louisiana Department of Wildlife and Fisheries and the FWS with efforts to establish this experimental population. Early results are promising; 17 additional cranes were introduced to the population in 2014 and cranes nested in Louisiana for the first time in 75 years.

Wind Energy Development – Units are conducting 13 different research projects related to wind energy development across the United States. Collectively, the projects are designed to facilitate "smart" development and placement of wind energy projects to minimize potential impacts and conflicts by identifying important species and habitats, establishing methods for monitoring and assessing impacts, and prioritizing research needs. In the Northeast, the Maine and Massachusetts Units are conducting

research along the North Atlantic coast to understand the potential impacts of offshore-wind energy development on marine species. The South Carolina Unit is developing an atlas of seabird nesting sites along the Southeastern United States to be used subsequently for spatial planning including site selection. The Wyoming, Colorado, and Nebraska Units are evaluating biological impacts of wind energy projects on birds and mammals near wind development sites. The Texas Unit is focused on the seasonal distribution and habitat use of golden eagles in relation to wind energy developments throughout their range to identify areas where potential conflicts are minimized.

Ecology of Sandhill Cranes – The New Mexico Unit in cooperation with Regions 2, 6, and 1 of the FWS, the Intermountain West Joint Venture, and biologists from state agencies in New Mexico, Idaho, Wyoming, and Montana is studying the ecology of Greater Sandhill Cranes that winter in the Middle Rio Grande Valley. This large-scale project encompasses this species' entire life history from the wintering grounds to the breeding grounds, including winter survival, habitat use, resource selection, bioenergetics to capture carrying capacity on the refuges and wildlife areas where they winter, timing of migration, use of fall and spring staging areas, and connecting winter habitat use to breeding success in Wyoming, Montana, and Idaho. This project will also be tied to complimentary projects going on in Arizona and in western Texas on other populations of Greater Sandhill cranes for a larger population level look at this species. Working with the Intermountain West Joint Venture, the Unit will develop landscape scale GIS models looking at changes in land use patterns over the past 50-60 years. The findings will enhance a larger model that will look at impacts of climate change as it relates to water availability on the breeding grounds where birds rely on flooded areas for successful reproduction and on wintering sites where birds depend on agricultural crops for food and flooded sites for roosts. Future water availability in the desert Southwest is an area of primary concern for this species and the Unit will be tying landscape level movement patterns from this study with historical, current, and future land use projections to provide information for State and Federal partners on how to manage and conserve this species into the next century.

Post Fire Habitat Quality and Selection by Salmonids – The 2010 Twitchell Canyon Fire burned approximately 18,000 hectares of Fishlake National Forest including significant portions of the Clear Creek watershed. Most of the fish were extirpated from the drainage because of fire-induced habitat impairment. The Utah unit is addressing primary research questions relative to the restoration of the native fish community affected by the Twitchell fire. This work ultimately will help both State and Federal resource managers prioritize habitat restoration efforts for this important native fishery.

Connecting People with Nature Through Science: The Wyoming Migration Initiative – The Wyoming Migration Initiative (WMI), spearheaded by the USGS Wyoming CRU in collaboration with Wyoming Game and Fish Department and other cooperators is designed to advance the

Ungulate migration pattern

understanding, appreciation, and conservation of Wyoming's migratory ungulates by conducting innovative research and sharing scientific information through public outreach. The initiative is comprised of five projects focused on understanding factors responsible for the decline of mule deer, an emergent problem in the Western United States. This effort will utilize GPS instrumentation of mule deer to understand their population dynamics and migration habits and the influence of environmental and anthropogenic factors including predation and energy development on population sustainability. WMI utilizes various media outlets such as Twitter and Facebook to connect the public to the ongoing work. Regular tweets have video footage of mule deer capture and instrumentation with GPS collars, and graphics displaying migratory movements. Public engagement in science efforts, such as the model fostered through WMI, will help ensure informed stakeholders and sustainable policy decisions.

2014 in Review – Achieving the Unit Mission

In 2014, Unit scientists and their cooperators advanced the mission of the CRU program through joint research, education, technical assistance, and science support. Unit scientists continued their productivity in 2014, with 876 active projects with Federal and State partners. Unit scientists and their students remained actively engaged in service to professional societies delivering 808 presentations. In addition, Unit scientists gave 39 invited seminars, indicating their research activities and findings are held in high regard by the scientific and management communities. The CRU's service to university cooperators continued to be strong, with 75 academic classes taught in 2014, and 34 additional workshops and short courses delivered to partners and cooperators.

Productivity Summary	**2011**	**2012**	**2013**	**2014**
Peer Reviewed Publications	349	358	369	329
Invited Seminars	56	69	51	39
Workshops and Short Courses	25	33	25	34
Total Projects (State+Fed+other)	793	862	881	876
Papers Presented	684	840	684	808
Academic Courses Taught	75	74	73	75
Total Number of Students	550	555	563	564
Master's Degrees Awarded	61	60	59	72
Doctoral Degrees Awarded	23	23	12	19

Each year, over 500 students engage in graduate education and training in natural resources conservation through the CRU program. About 15 percent of these students matriculate each year and enter the natural resources management workforce as employees of State and Federal agencies, non-governmental organizations, and universities. The number of advanced graduate degrees awarded to Unit students in 2014 was 91 (72 M.S. and 19 PhD).

The CRU program is dependent on participation and contributions of all signatory parties. In 2014, the CRU invested approximately 90 percent of program funding in scientists salaries and six percent in

administration, with all funding for research projects supplied by program partners. Of the 119 research scientist positions authorized for the program, 101 are currently funded and staffed. Improvements in program performance in the form of increased publications, students mentored and graduated, courses taught, and other product-oriented elements of scientific outreach are related to science staffing levels. Reinvesting in science capacity to fully-staff vacant Unit positions that, through attrition, now affect Units in 16 States will have a direct and near immediate benefit in improving the number of students the program can support and the distribution of scientific expertise available to address contemporary resource management needs.

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Climate and Land Use Change

Activity: Climate and Land Use Change

		2014 Actual	2015 Enacted	2016 Fixed Costs and Related Changes (+/-)*	2016 Internal Transfer	2016 Program Changes	2016 Budget Request	Change from 2015 (+/-)
Climate Variability								
National Climate Change & Wildlife Science		23,735	26,735	88	0	10,580	37,403	10,668
Center/DOI Climate Science Centers ($000)	FTE	39	42	0	0	14	56	14
Climate Research and Development ($000)		20,495	21,495	268	0	4,893	26,656	5,161
	FTE	116	120	0	0	14	134	14
Carbon Sequestration ($000)		9,359	9,359	54	0	9,100	18,513	9,154
	FTE	27	27	0	0	23	50	23
Subtotal: Climate Variability ($000)		**53,589**	**57,589**	**410**	**0**	**24,573**	**82,572**	**24,983**
	FTE	**182**	**189**	**0**	**0**	**51**	**240**	**51**
Land Use Change								
Land Remote Sensing ($000)		67,894	67,894	337	0	29,300	97,531	29,637
	FTE	141	141	0	0	2	143	2
Land Change Science ($000)		10,492	10,492	133	0	1,100	11,725	1,233
	FTE	53	51	0	0	5	56	5
Subtotal: Land Use Change ($000)		**78,386**	**78,386**	**470**	**0**	**30,400**	**109,256**	**30,870**
	FTE	**194**	**192**	**0**	**0**	**7**	**199**	**7**
Total Requirements ($000)		**131,975**	**135,975**	**880**	**0**	**54,973**	**191,828**	**55,853**
Total FTE		**376**	**381**	**0**	**0**	**58**	**439**	**58**

**Fixed Costs are $844 and Seasonal Federal Health Benefits are $36*

Summary of Program Changes

Request Component	($000)	FTE	Page
National Climate Change and Wildlife Science Center/DOI Climate Science Centers (CSCs)	**10,580**	**14**	
Climate Adaptation and Resiliency - Vulnerability Assessment Database & Field Guide	800	0	C-60
Critical Landscapes: Arctic	500	4	C-20
Interagency Coordination	2,250	4	C-60
Resilient Coastal Landscapes and Communities: Climate Outputs	500	2	C-29
Translational Science Grants	3,000	2	C-65
Tribal Climate Science Partnerships	2,500	0	C-66
WaterSMART: Drought	1,030	2	C-12
Climate Research & Development	**4,893**	**14**	
Emerging Science Needs	2,268	6	C-60
Grand Challenge: Climate & Land Cover Change Effects	1,500	3	C-60
WaterSMART: Drought	1,125	5	C-12
Carbon Sequestration	**9,100**	**23**	
Biological Carbon Monitoring and Tools	6,500	15	C-58
Biological Carbon Sequestration: Land Management	200	1	C-58
Ecosystem Services: Biological Carbon Sequestration	400	2	C-46
Grand Challenge: Carbon Inventory & Decision Support Tools	2,000	5	C-58
Land Remote Sensing	**29,300**	**2**	
Big Earth Data: Data Cube	600	0	C-48
Critical Landscapes: Arctic	250	1	C-20
Landsat Ground Systems Development	24,300	0	C-44
Landsat Science Products for Climate and Natural Resources Assessments	4,000	2	C-49
Resilient Coastal Landscapes and Communities: Imagery Datasets and Analytical Tools for Coastal Analysis	500	2	C-31
WaterSMART: Drought	250	1	C-13
WaterSMART: Remote Sensing	400	1	C-10
National Civil Applications Program	-1,000	-5	C-49
Land Change Science	**1,100**	**5**	
Ecosystem Services: Landscape and Climate Conditions	200	1	C-46
Natural Hazard Science for Disaster Response: Scenario Planning and Response	300	1	C-40
Resilient Coastal Landscapes and Communities: Coastal Land Use Change and Sea-level Rise	200	1	C-30
WaterSMART: Remote Sensing	400	2	C-10
Total Program Change	**54,973**	**58**	

Justification of Program Changes

The 2016 Budget Request for Climate and Land Use Change (CLU) is $191,828,000 and 439 FTE, a net change of +$55,853,000 and +58 FTE from the 2015 Enacted level. For more information on the CLU Mission Area changes, please see Section C, Program Changes as indicated in the table.

Activity Summary

The U.S. Geological Survey (USGS) plays a leadership role in providing critical science needed to inform decisionmaking for environmental management and for mitigating and adapting to climate change. In particular, the CLU Mission Area undertakes scientific research, monitoring, remote sensing, modeling, synthesis, and forecasting to understand the effects of climate and land use change on the Nation's natural resources better. The results provide a scientific foundation to inform decisions by resource managers, and policymakers at State, local, tribal, and national scales. The CLU Mission Area's core mission is to improve the understanding of past and present change and to identify those lands, natural resources, and communities most vulnerable to climate and land change, including impacts to fish, wildlife, ecological, and coastal processes.

The science needed for a landscape-level understanding of natural resources, and for improved understanding of, adaptation to, and mitigation of climate change, are top priorities for the Administration and the Department of the Interior (Interior). The CLU Mission Area has responsibility for—

- National Climate Change and Wildlife Science Center (NCCWSC)/Department of the Interior Climate Science Centers (CSCs) (*http://nccwsc.usgs.gov/*)
- Climate Research and Development (Climate R&D, *http://gcp.usgs.gov/rd/*)
- Carbon Sequestration (Biological: *http://www.usgs.gov/climate_landuse/land_carbon/;* Geologic: *http://energy.usgs.gov/HealthEnvironment/EnergyProductionUse/GeologicCO2Sequestration.aspx)*
- Land Remote Sensing (LRS, *http://remotesensing.usgs.gov/*)
- Land Change Science (LCS, *http://gam.usgs.gov/*)

The CLU Mission Area supports the following Interior 2014 – 2018 Strategic Plan goal to "Provide Science to Understand, Model, and Predict Ecosystem, Climate, and Land Use changes at Targeted and Landscape levels (biota, land cover, and Earth and ocean systems)." In particular, the CLU Mission Area supports the following two strategies: (1) "Identify and predict ecosystem and land use change," and (2) "Assess and forecast climate change and its effects." The goal of CLU programs is to be a primary provider of science needed for adaptation to and mitigation of the impacts of climate and land use change on Earth and human systems. Managers of U.S. land, water, wildlife and other natural and cultural resources use the results of USGS science to inform their planning and management decisions.

The CLU Mission Area programs also contribute to and coordinate with national and international scientific activities including the U.S. Global Change Research Program (USGCRP). The CLU Mission Area participates in various working groups that address topics such as fresh-water resources

management, climate-change decision support, and carbon sequestration. In addition, CLU Mission Area projects support the USGCRP goals to—

- Advance scientific knowledge of the integrated natural and human components of the Earth system.
- Provide the scientific basis to inform and enable timely decisions on adaptation and mitigation.
- Build sustained assessment capacity that improves the Nation's ability to understand, anticipate, and respond to global change impacts and vulnerabilities.
- Advance communications and education to broaden public understanding of global change, and empower the workforce of the future.

The *USGS Climate and Land Use Change Science Strategy: A Framework of Understanding and Responding to Global Change* (*http://pubs.usgs.gov/circ/1383a/*) outlines a number of high-level goals for CLU programs and is a vehicle for scientists and partners to get a general overview of our activities. The plan outlines seven broad goals and themes for USGS climate change science for the coming decade:

1. Rates, causes, and impacts of past global changes.
2. The global carbon cycle.
3. Biogeochemical cycles and their coupled interactions.
4. Land use and land cover change rates, causes and consequences.
5. Droughts, floods, and water availability under changing land use and climatic conditions.
6. Coastal response to sea-level rise, climatic change and human development.
7. Biological responses to global change.

The Mission Area's pursuit of these scientific goals—and USGS science more broadly—is policy relevant, but not policy prescriptive. For example, the CLU Mission Area is developing data and tools that can be used resource managers and city planners to support resilience planning for communities and ecosystems. An important tool is the series of Landsat satellites, which provide a consistent stream of data used by natural resource managers around the world to make water resource decisions, track forest health, and manage agriculture. Landsat data are used to document how local land use practices contribute to global change. For example, Landsat data were the first to quantify tropical deforestation, an insight that fundamentally changed Earth scientists' and public perception of the connection between land use and climate change. The USGS is currently developing Landsat-based science products to be updated every eight days for the United States, including surface temperature, fire disturbance, snow covered area, and green biomass. These datasets will support both natural resource managers and the climate monitoring community. The Climate Action Plan also encourages interagency coordination on climate change activities, which the CLU Mission Area does through the participation on USGCRP and the Council on Environmental Quality working groups that are addressing topics such as fresh-water resources management, climate change-adaptation decision support, and carbon sequestration.

Another aspect of the Climate Action Plan is the mandate for actionable climate science, which is a primary goal of the USGCRP. The CSCs are designed to meet through their climate vulnerability studies and database and through their "climate-adaptation strategies that promote resilience in fish and wildlife populations, forests and other plant communities, freshwater resources, and the ocean." CSC researchers (e.g., Federal, State, and university scientists) work closely with resource managers to define issues, identify science gaps, and co-conduct the research so the outcomes are directly usable. For example, scientists in the South Central CSC are developing a series of projects focused on drought impacts, including providing information to resource managers. In the Southwest CSC, scientists have started a project that will help us understand the linkages between drought and wildfire impacts. The Northeast CSC is implementing a project in 2015 to build climate-planning tools for tribal nations located in the Northeastern United States. The biological carbon sequestration project and Land Change Science Program also align closely with the Climate Action Plan focus on forest carbon measurement and projections. The Administration's new interagency forest carbon effort focuses on "managing our public lands and natural systems to store more carbon." With the U.S. Forest Service (USFS) and the U.S. Agency for International Development (USAID), the USGS provides Landsat satellite data, tools, and training to help developing nations inventory and track their forest resources and carbon stocks. Finally, the Climate Research and Development (R&D) Program conducts research to ensure that the processes through which climate change affects different aspects of the Earth system, including the Earth's paleoclimate history, are understood. For example, Climate R&D researchers are expanding the understanding of how climate variability and change have influenced water availability in the geologic past as well as in historical (instrumental) record. This includes documentation of regional to national patterns of droughts and floods, as well as the response of critical ecosystems to changes in water availability.

The CLU Mission Area manages the operation and delivery of land-surface information using data acquired by satellite and airborne instruments. A recent (2014) report by industry experts assessed the minimum annual value at roughly $2 billion in economic return on public investment in the Landsat satellite system. The budgets of both the USGS and NASA provide funding to sustain the Landsat data stream, which is critical to understanding global landscapes. The Landsat satellite program is funded at $77.6 million, $24.3 million above 2015, and includes funding for the maintenance and operation of ground systems and satellite operations. The successful launch of the Landsat 8 satellite in 2013 enables the continuation of the 42-year Landsat record. Following extensive study, the Administration has established a plan for a long-term Sustainable Land Imaging program that would extend the four-decade long Landsat series of measurements of the Earth's land surfaces for another two decades. The plan includes three simultaneous activities. The first is the initiation of a new U.S.-built small satellite with a thermal imager that would launch as soon as feasible, likely in 2019, and would operate either in conjunction with a European Sentinel-2 satellite or with the Landsat 8. The second activity would be the initiation of Landsat 9 as a rebuild of Landsat 8, with a target launch date in early 2023. The third activity is ongoing investment in technology development and systems innovation to reduce risk in next generation missions, including Landsat 10. In 2016, the USGS will work with NASA to support the Administration's plan for a Sustainable Land Imaging Program. The USGS is requesting $24.3 million to develop systems to operate the satellites and collect, archive, process, and distribute the data for the program. Additional funding requests to complete this effort will be made in future fiscal years.

Federal law requires the USGCRP to submit an assessment (the U.S. National Climate Assessment [NCA]) to the President and Congress once every four years on climate change and its impacts. In 2014, an NCA synthesis report was published with lead authors from the CLU on chapters that describe (1) changes in land use and land cover and how those changes affect the climate, and (2) impacts and adaptation for the Nation's ecosystems, water resources, the Southeastern United States, and Alaska. In addition to the NCA reports, several CLU-supported scientists served as lead authors of the Fifth Assessment Report (AR5) of Working Group II of the Intergovernmental Panel on Climate Change (IPCC).

The CLU Mission Area had many other notable accomplishments in 2014. With the release of the Eastern Report, the national biological carbon sequestration assessment for the lower 48 States was completed. The national biological carbon assessment is a national inventory of the capacity of land-based and aquatic ecosystems to naturally store or sequester carbon. Mandated by Congress in the Energy Independence and Security Act (EISA) of 2007 (P.L.110-140), the Eastern Regional report showed that forests, wetlands and farms in the Eastern United States naturally store 300 million tons of carbon a year (1,100 tons of Carbon dioxide, CO_2), which is nearly 15 percent of the greenhouse gas emissions that the Environmental Protection Agency (EPA) estimates the country emits each year, or an amount that exceeds and offsets yearly U.S. car emissions. The Eastern Regional report shows that the Eastern United States stores more carbon than the rest of the lower 48 States combined even though it has fewer than 40 percent of the land base.

The LandCarbon Atlas online tool was released to the public, enabling managers and the public to view, analyze and download carbon sequestration data via the Internet. This tool is a significant step forward in supporting ecological carbon sequestration management.

The latest edition of the National Land Cover Database (NLCD) *(http://www.mrlc.gov/)*, the Nation's most comprehensive look at land-surface conditions from coast to coast, was also released in 2014. The NLCD shows the extent of land cover types from forests to urban areas. Dividing the lower 48 States into nine billion geographic cells, the massive database provides consistent information about land conditions at regional to nationwide scales. Collected in repeated five-year cycles, NLCD data is used by resource managers and decisionmakers to conduct ecosystem studies, determine spatial patterns of biodiversity, trace indications of climate change, and develop best practices in land management. An assessment of trends in global forest cover change was completed in 2014, along with the fine-scale (250 m resolution) global mapping and classification of land cover, landforms, climate and surface geology. These 'first ever' products represent the most accurate, current, globally comprehensive assessments of the Earth's land surface.

In 2014, CLU scientists in collaboration with scientists from the Water Mission Area and academic researchers from the College of Earth, Oceanic and Atmospheric Sciences at Oregon State University, implemented the National Climate Change Viewer (NCCV) (*http://www.usgs.gov/climate_landuse/clu_rd/nccv.asp*). The NCCV is a Web site tool that provides citizens and resource managers an opportunity to understand and visualize different model projections of 21st century temperature and precipitation on a county-by-county basis. The NCCV also combines the

climate data with USGS water balance data to provide further insights into the potential for climate-driven changes in water resources on State, county, and watershed scales.

CLU scientists also collaborated with university scientists in Arizona and New Mexico to develop models of climate and habitat change through 2100 for 12 Southwestern bird and reptile species. Findings suggest two bird species may face local extinction by the end of the century and three reptile species may sustain range reductions of 40 percent over the same time period. A project like this helps provide landscape-scale understanding of the effects of climate change on wildlife and ecosystems.

Following the President's Commitment at the United Nations to provide assistance for global efforts to combat climate change, the LRS Program, in cooperation with the National Geospatial-Intelligence Agency (NGA), has made improved global topographic data publically available via the EarthExplorer portal *(http://earthexplorer.usgs.gov/)*. The broad availability of more detailed elevation data across the globe through the Shuttle Radar Topography Mission (SRTM) will improve baseline information that is crucial to investigating the impacts of climate change on specific regions and communities. Prior to the release of this data, only global coverage at 90-meter resolution was available. Since September of 2014, 30-meter data for Africa, North and South America, Pacific Islands, and northern Europe have been released through the EROS Center, with more areas to follow in 2015.

The CLU also produced its first climate data record, a surface reflectance product based on data from the Landsat 8 Operational Land Imager. This product reduces the processing time and increase accuracy for all users, and supports development of higher-order products such as surface water extent and wildfire burned area extent. In 2014, over 1.3 million surface reflectance products (116 terabytes) were distributed from the USGS Earth Resources Observation and Science Center (EROS).

Finally, in 2014 (and continuing into 2015), the CLU Mission Area began developing Landsat-based products to serve as Climate Data Records (CDRs) and related Essential Climate Variables (ECVs). The CDRs are long-term time-series measurements (surface reflectance, surface temperature) that support the development of ECVs such as snow covered area, land cover, biomass and measures of wildfire disturbance such as burned area extent. The CDRs and ECVs provide an authoritative, impartial basis for regional to continental scale identification of historical change, monitoring of current conditions, and prediction of future conditions.

Activity: Climate and Land Use Change

Subactivity: Climate Variability

Program Element: National Climate Change and Wildlife Science Center/Department of the Interior Climate Science Centers

2014 Actual:	$23.7 million (39 FTE)
2015 Enacted:	$26.7 million (42 FTE)
2016 Request:	$37.4 million (56 FTE)

Overview

Managers of natural and cultural resources need to understand the impacts of a changing climate, which can exacerbate ongoing stresses such as habitat alteration and invasive species, in order to design effective response strategies. The National Climate Change and Wildlife Science Center (NCCWSC) and the network of eight regional Climate Science Centers (CSCs) provide this understanding in the form of high quality, science-based tools and information. Partnering closely with managers of lands, waters, fish and wildlife, and other natural and cultural resources from start to finish in a research project ensures that NCCWSC/CSC-supported science is founded on stakeholder needs and that research products are ready for use.

The NCCWSC/CSC Program is closely linked to other USGS and larger Federal science capabilities and consists of Federal-university research centers to provide the varied expertise needed to address key resource management needs. All eight CSCs now have permanent Federal directors, and the partner universities' science staffing at each CSC continues to grow, allowing the CSCs to expand their science outputs, ensure effective links with each other and with partners, and conduct effective program operations. The CSCs are nearing the end of the first five-year agreements with their partners. The USGS will conduct an evaluation of the program prior to implementing new agreements to ensure that the goals of the program are being met as planned.

Strategic science planning at the CSCs begins with input from natural and cultural resource management partners in the region. Each CSC has a Stakeholder Advisory Committee (SAC) with representatives from the Department of the Interior Landscape Conservation Cooperatives (LCCs), other State and Federal agencies, and tribes, as well as other science providers in the region. All CSCs have five-year strategic plans that outline regional science priorities. These plans, with ongoing stakeholder input, are used to guide annual science planning and funding decisions. The CSCs will continue to focus on high-priority science that identifies potential impacts on natural and cultural resources, and will expand collaboration with other science providers in these focus areas. The NCCWSC has created a national science plan to provide a framework for the climate change- impact research conducted or coordinated by the NCCWSC. This plan also establishes a context for regional and national synthesis of science products and information across the CSC network. The NCCWSC federal advisory committee, the Advisory

Committee on Climate Change and Natural Resource Science (ACCCNRS), provided input to this national science plan, including developing recommendations on ways to increase the "actionable science" produced by CSCs, guidelines for interacting with tribal nations, and methods for evaluating the performance and effectiveness of the NCCWSC/CSC program.

The NCCWSC/CSC Program is a new approach to the way science is planned, conducted, and delivered. Overall, the CSCs' main goal is to provide actionable science that can be used for adaptation planning. New funding in 2016 would enable the program to expand its delivery of ready-to-use science, expand support for tribes planning for climate change, examine sea level rise impacts in the Southeastern United States and the Hawaiian Islands, examine changes in glacier loss in Alaska and effects on freshwater resources, and link Federal science efforts regionally to achieve maximum results with minimum duplication. Also in 2016, the NCCWSC/CSC Program would expand its work to address scientific and management issues associated with the ecological impacts of extreme and extended drought across CSC regions in the midcontinent and the Western United States. Much research is available on the effects of drought on human systems, notably agriculture, but the ecological effects are not as well studied. As research continues to indicate that the future will hold more intense and frequent droughts in many U.S. regions, it is critical to understand thresholds and tipping points and provide managers with early action options. The CSCs' proposal to bring together diverse stakeholders across a large region of the Nation would provide regional stakeholders with a science-based, integrative understanding of drought impacts to their resource management responsibilities, and of their potential adaptive management responses.

Program Performance

Continue to Focus on Meaningful and Significant Scientific Findings – NCCWSC and CSC projects initiated in earlier years of the program are coming to fruition and are providing meaningful and useful results, findings, data, and tools. In 2014, over 100 publications were released that resulted from NCCWSC/CSC-supported science projects, and this number is expected to significantly grow in 2015 and 2016 as projects are completed. The resultant scientific products span a large range of topics specific to the needs of stakeholders in each of the CSC's geographic regions. For example, a project completed in 2014 examined how climate change will affect growth rates of Chinook salmon, lake trout and steelhead in Lakes Huron and Michigan. The results from this study suggest that lake trout and steelhead will be better able to adapt to climate change than Chinook salmon, because of changes in prey fish availability. In 2014, work funded by the South Central Climate Science Center produced tools and data needed to predict tree species susceptibility to drought, climate change, and fire in the unique montane forests and woodlands of west Texas. In 2015, and continuing into 2016, Southeast CSC scientists will continue their work with the U.S. Fish and Wildlife Service (FWS) Refuge System to identify both refuge-level and coastwide opportunities to ensure adequate habitat for waterfowl populations in the face of rising sea levels and other challenges. The NCCWSC Web site provides details (*https://nccwsc.usgs.gov/*).

Providing Actionable Science – The NCCWSC/CSC Program focuses on providing scientific products, tools, and information, in response to the needs of resource managers. CSC products, by design, are policy relevant and directly applicable for use in the management of natural and cultural resources. The CSCs support a number of research projects that involve structured decisionmaking (SDM) as a core component. SDM and related methods help managers and scientists to identify and focus on the most

relevant information needed for a specific decision, thus enabling a more efficient use of scientific assets and ensuring greater utility of the results.

Scientists in the South Central CSC, for example, are developing a series of projects focused on drought impacts, including providing information to resource managers about how future precipitation will affect fire frequency and how that may impact species distribution in the south central United States. The South Central CSC is also developing better ways to communicate climate science and drought impacts and working with tribal communities to identify vulnerable resources and impacts of extreme events on those resources. In the Southwestern United States, drought and fire are two well-known hazards expected to increase in an era of climate change. A research project started in 2015 in the Southwest CSC will help to understand the linkages between drought and fire impacts by discovering how drought might weaken trees, leading to increased tree death following fires.

The Northeast CSC is implementing a project in 2015 (and will continue work in 2016) to build climate planning tools for tribal nations located in the Northeastern United States. Using results from the National Climate Assessment on Indigenous Peoples, this project will develop scenarios of possible climate-related change for six tribal nations in the Northeast Climate Science Center region. The scenarios will be used by tribal governments to develop adaptation plans for future management of resources within their jurisdictions. The North Central CSC is implementing a project, in part, on the Wind River Indian reservation to understand the different capacities for responding to drought impacts on grassland/rangeland, fish and wildlife, and forests management decisions affected by drought risk.

Regional/National Synthesis of Science – Individual CSC research activities are crucial for informing local management decisions, but also serve as the anchor for developing multi-regional perspectives (e.g., across the full range of a species or habitat). This landscape-scale science can provide the basis for multi-jurisdictional management strategies. National integration projects led by the NCCWSC build on CSC-level projects to understand larger trends in climate change impacts, synthesize regional information, and address species, habitats, and climate impacts that span multiple geographies. The NCCWSC conducts national-level syntheses of climate impacts for different topical and thematic areas. One example is a project completed in 2014, where the Southwest CSC collaborated with university scientists in Arizona and New Mexico to develop models of climate and habitat change through 2100 for 12 Southwestern bird and reptile species. Findings suggest two bird species may face local extinction by the end of the century and three reptile species may sustain range reductions of 40 percent over the same period. A project like this helps provide landscape-scale understanding of the effects of climate change on wildlife and ecosystems. Starting in 2015 (and continued into 2016), the NCCWSC will initiate a national synthesis project that will summarize our current understanding of drought impacts to ecosystems, plants and animals and the benefits people derive from them. This project will focus on stakeholder needs (natural resource managers, State fish and wildlife agencies, and conservation organizations) to prioritize information and scientific decision needs for managing the impacts of drought. Once completed, the project should identify and highlight science based approaches that have been used successfully to cope with drought.

Using new funds in 2016, the NCCWSC would initiate several regional-to-national synthesis activities with a focus on three key issues of high management interest. The first activity would highlight climate-

induced impacts to migratory birds and marine and coastal waterfowl. The second activity would build on the national synthesis project started in 2015, and would work with several CSCs' respective projects on the ecological impacts of drought. This would bring diverse stakeholders across the Western United States to a shared, science-based understanding of drought's regional impacts on their resource management responsibilities, and their potential adaptive management responses. Finally, the NCCWSC plans to work with other agencies and scientists to improve the guidance available to managers on the selection and use of future climate projections. The science of "downscaling" to obtain local projections of climate change has advanced rapidly, with many potential choices facing users. The NCCWSC would work with multiple partners, including USGS modelers, the U.S. Forest Service, and various groups organized to produce scenarios and climate model outputs under the auspices of the U.S. Global Change Research Program.

Next Generation Scientists/Managers – A core component of the NCCWSC/CSC Program is to ensure that decisionmakers are supported by well-trained scientists with an understanding of how to develop and communicate scientific findings that are relevant and applicable to future natural resource challenges. The CSCs currently provide support to approximately 100 undergraduate and graduate students in Science, Technology, Engineering and Mathematics (STEM) fields and post-doctoral researchers who contribute to CSC priority science work. The CSCs host and support a number of interactive training and collaboration workshops for students, early-career scientists, and resource managers. For example, in the Southeast CSC, a student was instrumental in developing the new Global Change Monitoring Portal. The Global Change Monitoring Portal aims to increase coordination among multiple Federal, State, and other organizations by providing a centralized, comprehensive catalog of Earth observation networks collecting data on southeastern aquatic and terrestrial ecosystems that may be influenced by climate change. In 2015 and 2016, the NCCWSC and CSCs will continue to place a strong emphasis on learning opportunities related to climate change impacts science.

Tribal Engagement – The NCCWSC and CSCs are committed to addressing the needs of Native American tribes and other tribal and indigenous communities for climate related information and adaptation planning tools. Tribal representation is an important component of both the CSC SACs as well as the ACCCNRS. The CSCs are working closely with the Bureau of Indian Affairs (BIA) to support placement of "extension agents" with the CSCs to support tribal adaptation planning. Work proposed in 2016 would build upon our relationship with the BIA and help to develop capacity to manage climate impacts to the natural resources managed by the tribes.

Drought – The NCCWSC and CSCs would expand work on drought impacts on fish, wildlife and their habitats. Building upon the cross-CSC drought research begun in 2015, the NCCWSC and CSCs would develop another strategic working group of stakeholders and managers to identify science needs in support of drought managers. The new work would focus on efforts within the Southwest CSC to understand the implications of long-term mega-drought impacts on resources in southern California and the Southwestern United States. Specifically, the program would integrate results from climate-driven drought projection models into models of ecological flow and wildlife impact to understand which areas of the country are more vulnerable to drought impacts. This work would make use of existing decision-support tools and expertise from the Land Change Science Program, and would be enhanced by expanded Climate Research and Development Program research on paleoclimate records of past mega-drought.

Coastal Resilience and Sea Level Rise – The NCCWSC/CSC Program, working closely with the USGS Coastal and Marine Geology Program (CMGP), would use the requested funding increase to bring structured decisionmaking approaches that integrate the latest sea-level rise projections to refuge and other land managers in the Southeastern United States, the Hawaiian Islands, and the west coast. Specifically, the program would identify management endpoints for land managers in coastal zones and develop models and approaches that link climate outputs with decision-based models. The land managers would then use this information in decisionmaking in areas such as restoration of habitat or protection or conservation of species.

Arctic – The Alaska CSC would use the requested funding increase to develop a process to estimate total glacier loss in Alaska and potential changes in freshwater flows. These estimates would be used with projections of future changes in climate, fire regimes, vegetation, and water flows, produced by the program's recently completed Alaska Integrated Ecosystem Model (AIEM). The AIEM is an ecosystem model for Alaska and Northwest Canada. This modeling tool is capable of forecasting how landscape structure and function might change in response to climate changes. These landscape change scenarios can then be used by resource-specific impact models to assess the effects of climate change on natural resources. The information from the requested funding increase would be used by managers from the FWS, BLM, and State of Alaska for high priority species such as migratory waterfowl, near-shore fisheries and caribou to identify potential impacts and identify management options.

National Climate Change and Wildlife Science Center

(2014 Actual, $4.2 million; 2015 Enacted, $5.5 million; 2016 Request, $9.3 million)

The NCCWSC manages the operations of the eight CSCs, and leads additional research and assessment activities related to climate impacts on fish, wildlife and their habitats. NCCWSC scientists are managing a national effort to identify overall impacts of climate change on fisheries in the United States, assessing the coverage of vulnerability assessments undertaken by Interior, and will provide critical integration of efforts at CSCs addressing drought, migratory birds, and downscaled climate modeling.

Department of the Interior Climate Science Centers

(2014 Actual, $19.5 million; 2015 Enacted, $21.2 million; 2016 Request, $28.1 million)

The eight CSCs, established between 2010 and 2012, provide information needed by natural and cultural resource managers to understand and adapt to a changing climate. Each CSC is a Federal-university collaboration, and develops a science portfolio in consultation with regional resource managers and science partners. In December 2013, the eighth and final permanent CSC Director at the Pacific Islands CSC was hired. The focus is now on increasing the CSCs' science capabilities and linkages with partner science agencies, and continuing to identify and prioritize science areas that will benefit from integration across CSC regions.

Listed below are the locations and host institutions of each of the eight CSCs:

DOI CSC (date established)	**Host Institution**
Alaska (2010)	University of Alaska
Northwest (2010)	Multi-institution consortium headed by Oregon State University
Southeast (2010)	North Carolina State University
Southwest (2011)	Multi-institution consortium headed by University of Arizona
North Central (2011)	Multi-institution consortium headed by Colorado State University
South Central (2012)	Multi-institution consortium headed by University of Oklahoma
Northeast (2012)	Multi-institution consortium headed by University of Massachusetts, Amherst
Pacific Islands (2012)	Multi-institution consortium headed by University of Hawaii, Manoa

Activity: Climate and Land Use Change
Subactivity: Climate Variability
Program Element: Climate Research and Development Program

2014 Actual: $20.5 million (116 FTE)
2015 Enacted: $21.5 million (120 FTE)
2016 Request: $26.7 million (134 FTE)

Overview

The Climate Research and Development Program (Climate R&D) conducts research to advance the understanding of the physical, chemical, and biological components of the Earth system, the causes and consequences of climate and land use change, and the vulnerability and resilience of the Earth system to such changes. Climate R&D Program researchers draw on expertise in past climate, geology, hydrology, geography, and biology to document patterns of climate and land use change on daily to millennial timescales and to assess and model the impacts of changes on local, regional, and national spatial scales. This research provides the basic data needed to understand how the Earth system has responded to a range of climate and environmental changes throughout its history. By integrating these data with modeling efforts, Climate R&D Program researchers are improving the understanding of impacts of climate and land cover change on critical habitats and ecosystems. These efforts also provide a means to evaluate model performance and improve our ability to forecast likely changes under a range of climate and land use scenarios.

Climate R&D Program activities are planned and conducted over five-year increments to address specific research questions. This strategy provides sufficient time and stability for projects to accomplish their stated goals and produce products and outcomes. It also provides the Climate R&D Program with the flexibility to address emerging critical issues (such as hydrologic extremes of drought and flooding) by coordinating among existing areas of expertise to establish appropriate research teams. Climate R&D Program research supports national and international efforts to understand climate change, such as the U.S. Global Change Research Program Strategic Plan, U.S. National Climate Assessment, and the Intergovernmental Panel on Climate Change.

The Climate R&D Program continues to fund climate change research needed to understand the patterns of climate and land use change and their impacts on the Earth system. Climate R&D Program research is broken out into eight focus areas: abrupt climate change; carbon cycle; climate data and model integration; documenting patterns and magnitudes of natural climate variability; hydrologic extremes (patterns, causes, and impacts); impacts of climate and land use change on terrestrial and marine systems; rates, causes, and consequences of land use and land cover change; and sea-level rise and coastal regions. Detailed information about each of these focus areas and their respective projects can be found on the Climate R&D Program Web site (*http://www.usgs.gov/climate_landuse/clu_rd/*).

In 2014, the Climate R&D Program conducted research to improve the understanding of the impacts of climate and land use change by conducting multidisciplinary research and modeling efforts in key habitats, including wetlands, mountains, and coastal areas. Those efforts were continued in 2015, and new research was initiated to address emerging science needs, including drought, rates and magnitudes of sea level rise, and response of coastal habitats to changing climate and sea level. In 2015, the Climate R&D Program began research to improve the understanding of feedback between climate and land use change, initially focusing on the Florida peninsula. In 2016, the Climate R&D Program would expand the new efforts from 2015 that focused on emerging science needs and effects of land cover change and initiate new research to study long-term (centennial-scale) and medium-term (multi-decadal scale) patterns of drought. This research would focus on documenting long-term and medium-term patterns of drought and water availability in the Western and Southeastern United States. It is critical to understand decadal- to centennial-scale patterns of drought, how they are influenced by climate variability and human activities, and their impacts on our Nation's ecosystems because responding to drought and managing the implications of limited water resources are primary drivers for many land and water management agencies.

Program Performance

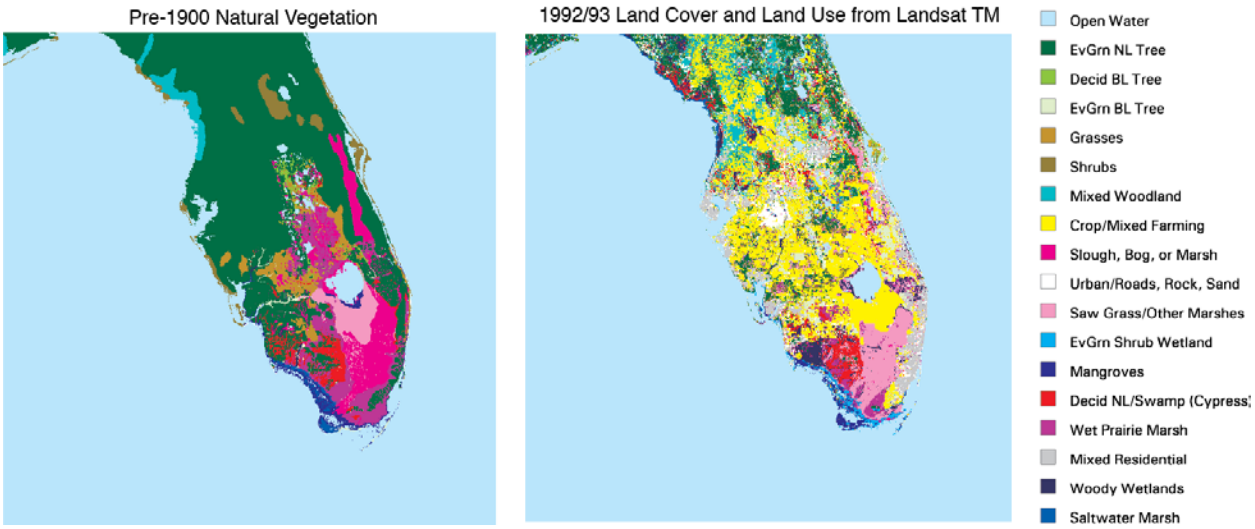
Documenting Historical Levels of Climate Variability on Regional to National Scales – The USGS has a long history of research designed to document long-term patterns of climate variability across the Nation. In 2011, the Climate R&D Program began a new initiative to establish historical North American climate baselines based on paleoclimate and instrumental records. In 2015, Climate R&D continued to develop long-term records of temperature and moisture availability from a national network of sites. Researchers also identified regional data gaps; the lack of adequate records in these areas will impede efforts to understand how atmospheric and ocean processes interact to influence North American climate. They began synthesizing local and regional data to improve understanding of long-term patterns of drought, storms, and other climate variables on a national scale. In 2016, Climate R&D scientists would begin developing new records from data-sparse regions to fill in gaps identified in 2015. They also would use results from synthesis efforts in the Western United States to document how atmospheric and ocean processes interact to affect climate patterns. Working in collaboration with climate modeling groups in Federal and academic institutions, Climate R&D scientists would provide such data to improve capabilities to model and forecast impacts of different climate and land use scenarios in the Western United States and, ultimately, across North America.

Improve Understanding of Potential Rates and Magnitudes of Sea-Level Rise – Sea-level rise and associated storm surges are major threats to low-lying areas of U.S. coastal zones; the possible rates and magnitudes of sea-level rise due to loss of major ice sheets, alpine glaciers, and regional tectonics are a pressing concern. Since uncertainties exist regarding the potential contributions of those factors to sea-level rise, the Climate R&D Program began research on geologic records of high sea level in 2014. Initial efforts focused on the Pacific coast of the United States; in 2015, this was expanded to include the Atlantic coast. In 2016, expanded field efforts on both coasts would be conducted to improve capabilities to model future rates and patterns of sea-level rise; this work would be conducted collaboratively with Federal, State, and academic researchers. In 2014, Climate R&D researchers also began developing methods to consistently quantify the amount of water contained within alpine glaciers. Initial results from

comparative analysis of two Alaskan benchmark glaciers have revealed differences in variability and trends between coastal and continental sites. In 2015, these comparisons will be expanded to benchmark glaciers in the Pacific Northwest. In 2016, new techniques would be utilized to consistently measure water contained within other alpine glaciers, improving understanding of the potential contributions of melting glaciers to sea-level rise and supporting expanded research planned by the Alaska Climate Science Center.

Increase the Understanding of the Impacts of Climate and Land-Use Change on our Nation's Ecosystems – Climate R&D Program research uses a combination of process-based research and monitoring to document past ecosystem variability and model potential ecosystem response to different climate and environmental stressors. In 2014, Climate R&D Program researchers initiated research and modeling efforts in key habitats that include wetlands and coastal habitats in the Southeastern United States and the Western mountains. The projects focus on energy and nutrient flow through ecosystems over long timescales and will record the impacts of both natural climate variability and land cover change. These efforts were expanded in 2015, and include collaboration among Climate R&D researchers, Climate Science Centers, resource managers, and policymakers to provide the scientific basis to develop sustainable management policies for these habitats. In 2016, Climate R&D researchers would expand their efforts into the mid-Atlantic region and the Gulf Coastal Plain. This would provide new evidence on how drought and other climatic and environmental changes affect critical processes such as water table recharge, nutrient filtration, and carbon sequestration. The collaborative effort with resource managers in national parks and refuges would help guide development of sustainable resource management strategies for the Nation’s coastlines.

Improving Understanding of Feedbacks between Land-Use Change and Climate – Humans have modified the Earth’s surface for thousands of years through activities such as forest clearance, expansion of agriculture, drainage of wetlands, and alteration of river flow. For example, in the Florida Everglades, land use and water management practices of the 20th century significantly reduced the extent of lakes and wetlands. Such land cover changes can alter regional climate patterns and cause the boundaries between wet and dry regions to shift, altering local to regional vulnerability to droughts and floods. In 2015, Climate R&D researchers initiated new research to improve understanding of how feedback between land-use change and climate affect climate and hydrology in the Florida peninsula. Scientists began developing high-resolution land cover datasets that realistically portray soil moisture and the water cycle for the present day and pre-colonial time by combining historical records of land change with modern satellite records. In 2016, Climate R&D researchers would finalize these datasets and begin working with climate modelers to identify how land-cover change alone affects temperature, precipitation, and other climate variables. This research would inform management and response to changes in the region’s hydrology and ecology. In 2016, new research also would be initiated in the upper Colorado River basin, building on knowledge gained from research on the Florida peninsula to provide new insights on water supply, demand, and drought. Results from these efforts ultimately would be coupled with other modeling efforts to improve forecasts of future climate changes that would result from specific land-management strategies, thus supporting the Climate Science Centers’ work on drought in the Western United States.



Comparison of reconstructed land cover before significant alteration of the Florida landscape (pre-1900) and land cover in 1992-93 based on Landsat imagery (from Marshall et al., 2004).

Improving Understanding of Climate Patterns and Drought – Understanding spatial and temporal patterns of drought is critical to develop sustainable management plans for use of limited water. In 2015, Climate R&D scientists continued to generate data to improve understanding of long-term patterns of water availability at study sites across the Nation. In 2016, the Climate R&D Program would expand its research on long-term (centennial-scale) and medium-term (multi-decadal scale) patterns of drought. This research initially would focus on regional syntheses of long-term patterns of drought and its impact on ecosystems and biogeochemical cycling in the Western and Southeastern regions, in concert with ongoing and proposed work by Climate Science Centers. Documentation of patterns of water availability and droughts during the last few thousand years would provide a context to assess the magnitude and regional impacts of current and future droughts. It would also provide evidence of the impacts of drought on critical landscapes. Such evidence provides resource managers with real-world results that can be used to test results from a range of climate and ecosystem models. This effort would also build upon a Climate R&D project that began in 2015 to improve the understanding of impacts of land cover change on regional climate and hydrology. The integration of these efforts would allow modelers and resource managers to understand and forecast how local and regional hydrology and ecosystems would respond to drought, land-use changes, and a range of management scenarios.

National Climate Change Viewer (NCCV) – in 2014, the Climate R&D Program launched the NCCV, a climate-visualization website tool that gives citizens and resource managers the opportunity to look at climate-driven impacts on watersheds and map projected changes at the local, regional, state and watershed levels (*http://www.usgs.gov/climate_landuse/CLU_rd/nccv.asp)*. The Climate R&D Program designed and implemented the tool in collaboration with the Water Mission Area and academic researchers from the College of Earth, Oceanic and Atmospheric Sciences at Oregon State University. The tool was developed in two phases. The first phase allows the user to understand and visualize different model projections of 21st century temperature and precipitation on a county-by-county basis.

The second phase, coupled previous outputs with USGS water balance models to translate the results into hydrologic projections for U.S. States, counties, and watersheds. The viewer provides a way to simulate the response of water balance to changes in temperature and precipitation in climate models and to yield insights into the potential for climate-driven change in water resources. The National Climate Change Viewer and data are being used by federal agencies, including the USGS and National Park Service, to examine the potential effects of climate change on aquatic and terrestrial ecosystems in parks and regions throughout the United States.

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Activity: Climate and Land Use Change
Subactivity: Climate Variability
Program Element: Carbon Sequestration

2014 Actual: $9.4 million (27 FTE)
2015 Enacted: $9.4 million (27 FTE)
2016 Request: $18.5 million (50 FTE)

Overview

Carbon sequestration is a method of securing carbon dioxide (CO_2) to prevent its release to the atmosphere and its contribution to global warming as a greenhouse gas (GHG). Geologic storage of CO_2 in porous and permeable rocks involves injecting high pressure CO_2 into a subsurface rock unit and displacing or dissolving into the fluid that initially occupied the pore space. Biological carbon sequestration refers to both natural and deliberate processes by which CO_2 is removed from the atmosphere and stored as carbon in vegetation, soils and sediments. The Energy Independence and Security Act (EISA) of 2007 (P.L. 110-140) called for the USGS to develop a methodology for and then complete a national assessment of geologic storage capacity for CO_2. The legislation also required the Secretary of the Interior to complete a quantitative national assessment of the carbon stored in and released from ecosystems. The Carbon Sequestration Program is responsive to the EISA and supportive of the President's Climate Action Plan, which highlights the need for unlocking long-term investment in many energy commodities, and innovative technologies to address the avoidance, reduction, or sequestration of anthropogenic emissions of greenhouse gases.

In 2013, the geologic carbon sequestration project completed and published the first-ever comprehensive, fully probabilistic and quantitative assessment of the potential for geologic carbon sequestration in the United States (USGS Circular 1386, *http://pubs.usgs.gov/circ/1386*). The assessment indicates that there are ample geologic storage resources available for carbon capture and sequestration technologies outlined in The President's Climate Action Plan. During 2014, numerous presentations and briefings describing the results of the geologic storage assessment were made at national and international scientific conferences and to various government and industry groups.

The EISA also requested the USGS to evaluate the national technically recoverable hydrocarbon resources resulting from CO_2 injection and storage through CO_2-enhanced oil recovery (CO_2-EOR). Anthropogenic CO_2 captured from industrial sources is currently being used to recover oil from some reservoirs. The utilization and storage of captured of CO_2 helps to decrease the carbon footprint of the produced oil. In 2014, the geological carbon sequestration project developed an assessment methodology and plans to conduct a national assessment of the volumes of recoverable soil and resulting in CO_2 storage associated with CO_2 EOR in the next three years. The project also conducts research to better define the geologic controls on CO_2 storage in geologic reservoirs.

In 2014, the biological carbon sequestration project published their third regional assessment, the Eastern United States (USGS Professional Paper 1804, *http://pubs.usgs.gov/pp/1804/*).

The biological carbon sequestration project has developed an innovative methodology to incorporate Landsat satellite data, develop models and tools, and collect field observations in testing these tools. In 2015, work will focus on the development of tools for use in land management applications. In this effort, the USGS will actively engage the CSCs and Interior land management agencies, such as the U.S. Fish and Wildlife Service (FWS) and Bureau of Land Management (BLM), and partner with them to develop fine-scaled applications. These applications include monitoring the impacts of land use decisions on carbon sequestration and other greenhouse gas emissions, and developing mitigation and adaptation scenarios. USGS scientists are already working with the FWS to use the assessment results in support of National Wildlife Refuge (NWR) restoration activities in eastern coastal wetland ecosystems, including Great Dismal Swamp and Pocosin Lakes. Enhanced carbon storage, wildlife habitat, and improved water quality from these wetlands are among key ecosystem services being addressed.

In 2015, the biological carbon sequestration project will complete the Alaska and Hawaii assessments, providing comprehensive ecosystem carbon estimates for the first time in the two states. It will also begin work on a "grand challenge" implementing a carbon inventory and tracking system for carbon stocks and flows on all Interior lands, complete with online tools to support regional natural resource decisionmaking.

Geologic Carbon Sequestration

(2014 Actual, $4.2 million; 2015 Enacted, $4.2 million; 2016 Request, $4.2 million)

In 2010, the USGS published an assessment methodology (*http://pubs.usgs.gov/of/2010/1127/*) to estimate carbon sequestration-storage potential suitable for uniform application to geologic formations throughout the United States. The USGS methodology, a unique, robust approach to assessing the CO_2 storage potential of individual storage assessment units in sedimentary basins, is a geology-based, probabilistic methodology. The International Energy Agency and representatives from multiple international geological surveys endorsed the methodology and recommend that regional-scale assessment of geologic CO_2 storage capacities should follow the USGS methodology. The results of the USGS national CO_2 storage assessment, which were released in 2013 (*http://pubs.usgs.gov/circ/1386/*), reported that the United States has 36 underground basins that could store 3,000 metric gigatons of CO_2. Those resources could be used by carbon-capture technology applied to coal-fired power plants and other industrial CO_2 sources to reduce carbon emissions. For comparison, the U.S. Energy Information Administration reports that the United States emitted 5.2 metric gigatons of energy-related CO_2 in 2012. Although the potential for sequestration described in this assessment is unprecedented, injecting CO_2 into geologic formations is not a new process or technology. Carbon dioxide injection has been one method used in enhanced oil recovery since the 1980s. This study provides new information needed for the potential management of CO_2 by various means. Project activities in 2015 focused on the completion and publication of scientific reports that (1) describe the geologic models that formed the basis of the national CO_2 storage assessment, and (2) provide a summary of general land ownership and Federal lands overlying assessed storage areas.

The EISA also requests that the USGS, the U.S. Department of Energy (DOE), and other agencies coordinate efforts to conduct research related to geologic carbon sequestration. The USGS has unique expertise needed to understand the injection of CO_2 into saline formations, as well as provide baseline information in order to understand potential seismicity induced by sequestration activities. As geologic carbon sequestration implementation begins, Interior land and resource managers will need this research and subsequent assessments to plan for future leasing activity and the Environmental Protection Agency (EPA) will use it to better predict and inform the permitting process. The DOE uses products from this research in their Annual Energy Outlook predictions and as a foundation to plan future demonstration projects. All of this work aligns with a 2012 National Research Council Report (*http://www.nap.edu/catalog.php?record_id=13355*) that recommended that the USGS work with other government and private agencies to collect new data to better understand the risks associated with injection of CO_2 into deep saline formations.

After the completion of the national CO_2 geologic storage assessment reports, a new phase of the geologic carbon sequestration project (GCSP) began in 2014. The new GCSP plans were reviewed and approved by USGS, academic, and industry experts. A primary focus of the new GCSP, as required by the EISA, is on the national technically recoverable hydrocarbon resources resulting from CO_2 injection and storage through CO_2-EOR. In addition, the project addresses several other areas of carbon sequestration research that include study of natural CO_2 and helium reservoirs as analogues for anthropogenic CO_2 storage, the economics of CO_2 storage and CO_2-enhanced oil recovery, and induced seismicity associated with CO_2 geologic storage. Project activities in 2014 and 2015 focused on the completion and publication of scientific reports that describe the geologic models that formed the basis of the national CO_2 storage assessment. During 2014 and early 2015, eight basin reports were published that describe the geology of the storage assessment units in sedimentary basins in the United States (*http://pubs.usgs.gov/of/2012/1024/).* In addition, a report summarizing general land ownership and Federal lands overlying assessed storage areas is scheduled for publication in 2015.

In 2016, the geologic carbon sequestration project would continue work to estimate recoverable hydrocarbons associated with CO_2-EOR in potential storage formations in the United States. A comprehensive national reservoir engineering and geologic database, developed in 2013, and quality checked in 2014, helps to determine which U.S. reservoirs may be available for the CO_2-EOR process. In 2014, the USGS completed a draft of the assessment methodology for assessing the technically recoverable oil and gas resulting from carbon sequestration associated with CO_2-EOR. Once a panel of experts reviews the methodology, in 2015, the USGS would start a three-year national assessment of recoverable hydrocarbons resulting from CO_2-EOR. The Helium Stewardship Act of 2013 (P.L. 113-40) also requested that the USGS work with the Bureau of Land Management (BLM) to assess the availability of technically recoverable natural helium and CO_2 found in many natural gas reservoirs. The national resources of recoverable natural helium and CO_2 in the United States are poorly defined and would be evaluated along with industrial CO_2. Cooperative data industry sharing agreements were developed in 2014 to allow project and industry scientists to evaluate gas geochemical data that can be used to evaluate natural helium and CO_2 resources in the United States. The USGS would continue to develop economic assessment methodologies in 2016 to evaluate the results of both the 2013 national geologic carbon sequestration assessment and the national assessment of recoverable hydrocarbons resulting from carbon sequestration associated with CO_2-EOR. Research activities will continue on the

identification of the controls on geologic CO_2 storage, issues related to storage of CO_2 in unconventional reservoirs (primarily coal), and the potential impacts of induced seismicity on storage of CO_2.

The USGS is currently investigating the possible causes of induced seismicity related to the subsurface injection of fluid CO_2 and plans to continue this work in 2016. The significance of induced seismicity associated with wastewater disposal from natural gas production has been highlighted by recent USGS research; likewise, there is a potential seismic hazard associated with geologic carbon sequestration projects. The primary focus of the CO_2 sequestration induced seismicity research will be on the operation of an independent USGS seismic monitoring network (installed 2013-2014) at the largest operating underground CO_2 injection and storage facility in the United States, located in Decatur, Illinois. Data collected from the USGS seismic monitoring installation at Decatur will be used to interpret the potential seismic hazard associated with geologic CO_2 sequestration in the Illinois Basin and in similar geologic settings such as at the proposed Illinois Basin FutureGen project. Leveraging collaborative research and data sharing with these demonstration efforts is critical for expanding the knowledge of fate and behavior of CO_2 in the subsurface, which can then be used to refine future assessments and understanding of potential risks. Initial results from the USGS seismic monitoring installation at Decatur published in 2014 indicate that recorded microseismic events occur relatively far from the reservoir caprock and likely do not compromise the integrity of the seal (*http://dx.doi.org/10.1016/j.egypro.2014.11.461*).

Finally, the USGS in 2016 would continue to conduct focused detailed geologic studies of reservoirs and seals in selected basins with high potential for carbon sequestration or that have demonstrated capacity to trap naturally occurring CO_2. For example, a Cooperative research and Development Agreement with a major industrial electric utility company will allow the investigation of potential CO_2 storage sites in the Southeastern Unites States. More information is needed on geological formations to ensure safe and long-term storage of CO_2. Research in the U.S. midcontinent region would also include characterizing variations in reservoir temperature and pressures related to CO_2 injectivity and storage. The USGS would also work with government and industry partners to investigate the effects of subsurface CO_2 injection on water and rock chemistry for enhanced oil and gas recovery, geologic carbon sequestration, and naturally occurring CO_2 reservoirs. Very little is known about the effects of injecting high pressure, liquid CO_2 into the subsurface and the changes it will cause there. Collaborative efforts will continue with industrial partners, State Geological Surveys, universities, the U.S. Department of Energy National Energy Technology Laboratories (DOE NETL) Regional Carbon Sequestration Partnerships, BLM, and the EPA.

Biological Carbon Sequestration

(2014 Actual, $5.2 million; 2015 Enacted, $5.2 million; 2016 Request, $14.3 million)

The USGS released the biological carbon sequestration-assessment methodology in 2010. A wide range of stakeholders view this assessment as a major advance in the scientific understanding of the relationships between ecosystem capacities to store carbon (or ecosystem vulnerability to release carbon into the atmosphere) and natural and anthropogenic processes, particularly land use change, ecosystem disturbances, management practices and climate change. All major ecosystems are included in the assessment, including forests, agricultural lands, grasslands, wetlands, rivers, lakes, and estuaries. By design, the biological assessment is conducted on a regional basis: Great Plains, Western United States, Eastern United States, Alaska, and Hawaii.

The USGS has already completed and delivered the Great Plains (December 2011), the Western United States (November 2012), and the Eastern United States (June 2014) regional assessments. The Great Plains, Western United States, and Eastern United States assessments confirmed that all three regions are "carbon sinks," meaning their ecosystems take up more carbon than they emit. Eastern ecosystems are the strongest regional carbon sink in the conterminous United States, sequestering more carbon than the rest of the area combined. On a national scale, the amount of carbon that is currently stored per year in the ecosystems of the conterminous United States is over 20 percent of the Nation's total greenhouse gas emissions.

The assessments of Alaska and Hawaii are currently being conducted, with initial results analyzed and being prepared for peer review; the reports are expected for release by the end of fiscal year 2015. These reports will complete the assessment for the entire United States. This is the first time these two States have been included in a major national-scale reports such as the annual Environmental Protection Agency greenhouse gas inventory report. This provides critically needed information that was not previously available about the status and trends of carbon stored in their ecosystems, the carbon and methane emitted from wet soils and permafrost, as well as the impacts of fire and quickly changing climate conditions.

In 2014, the USGS released the LandCarbon Atlas online tool to the public, enabling managers and the public to view, analyze, and download carbon sequestration data via the Internet. This tool is a significant step forward in supporting ecological carbon sequestration management. Further development of this tool in 2015 and 2016 will allow land managers to ask "what-if" questions regarding the impacts of potential land management activities on carbon stocks and sequestration capacity, as well as on other ecosystem services (such as biodiversity, water quality, etc.). Data products (including carbon stock and sequestration estimates, emissions and fluxes in and out of ecosystems, land use change, and wildland fire) for the conterminous United States are now available for analysis and download via the Internet (landcarbon.org).

In 2015, the USGS will continue work started in 2014 to develop an enhanced decision support system to quantitatively assess which areas should get the highest priority for afforestation, reforestation and restoration activities. The USGS is prototyping the system at Great Dismal Swamp National Wildlife Refuge. The system, once completed, will allow land managers to use USGS science data to examine scenarios and ask what-if questions about the outcomes of specific land management decisions on the carbon cycle. The USGS and the FWS are developing this tool to incorporate ecological carbon sequestration into refuge management and restoration activities in eastern coastal wetland ecosystems including the Great Dismal Swamp and Pocosin Lakes refuges. In 2016, the USGS and the FWS would expand these pilots to include Nisqually, Neal Smith, Yukon Flats, and Ding Darling National Wildlife Refuges. For these sites, USGS scientists are focusing on key ecosystem services from these wetlands in consultation with local and regional stakeholders.

In 2015, and continuing into 2016, the USGS will work on high-priority areas authorized by EISA and emphasized in the President's Climate Action Plan. This includes completing the assessments in Alaska and Hawaii, developing capabilities to routinely and reliably update the assessments to provide a steady source of scientifically credible and policy relevant information, attributing impacts on biological sequestration capacity, and working closely with land management agencies of the Department of the

Interior in support of their carbon sequestration and climate mitigation actions using the assessment results. A suite of implementation projects will be conducted in partnership with land management agencies through the Department of Interior's newly organized Land Carbon Working Group. Various mitigation scenarios will be tested, including expanding conservation areas and management practices; increasing intensive forest management; increasing restoration activities in coastal carbon-rich wetlands; and enhancing ecosystem resilience to reduce emissions of carbon dioxide and methane from disturbances. As with the pilot studies begun in 2014, stakeholder workshops will be conducted to incorporate local knowledge and priorities into tools that accurately value ecosystem services and enable land managers to make decisions based on the best available scientific information. Interagency agreements and partnerships will be developed to ensure that these data and tools will achieve practical uses in day-to-day land management decisionmaking.

The USGS biological carbon sequestration assessment for Alaska includes significant research on boreal and arctic ecosystems. In 2015 and 2016, the USGS will continue to conduct research and provide data on relationships and feedback loops between warming temperatures in Alaska, permafrost, wildfire, change in surface hydrology, and the fate of the existing and future strength of the Alaska carbon sink. The Climate and Land Use Change Mission Area has supported the development of a wall-to-wall detailed permafrost map, and research is underway on methods to track change in permafrost and active layer thickness using innovative remote sensing methods. The USGS is leveraging these research products in a collaboration program with the FWS and the NASA Arctic-Boreal Vulnerability Experiment (ABoVE). This collaboration will result in complementary data collection in 2015 and 2016, which will fill in data gaps and support a more complete first Alaskan greenhouse gas inventory and more accurate future carbon projections.

In 2015 and 2016, the USGS will also continue investigations into attribution of causes of change in carbon sequestration and into quantifying uncertainties in the carbon sequestration assessment. In addition, progress will be made in operationalizing an innovative land change detection procedure developed by Boston University through support from the Land Remote Sensing Programs. The Land Change Monitoring Assessment and Projection approach uses all observations made throughout the lifetime of the Landsat satellite series to identify areas of land change on an annual basis and will inform assessments of changing biological carbon sequestration capacity.

The proposed increases in 2016 would be used to improve the enhanced decision-support system to increase the applicability of carbon sequestration information in land management decisions. Research would be conducted jointly with DOI's land management agencies (FWS, BLM and NPS) to insure that results are readily incorporated into management decisions. Specific activities would include conducting:

1. **Pilot studies on Federal lands, characterizing regional stakeholders' values for specific ecosystem services and quantify effects of management activities** – The findings from these pilots would be used to guide the development of the online tool. Thus, as more pilots are completed, the insights gained would be building blocks in understanding land management options and their effects for major types of Federal lands and across large landscapes. The pilots would also be used to assess the impacts of Interior's land management practices. Specific pilots include assessing thermokarst disturbance in interior Alaska, restoration of coastal wetlands threatened by sea-level rise on the Puget Sound and Pacific coast, mine reclamation in the Midwest, and the expansion of mangroves in Florida.

2. **Finer-scale analyses on the role of mediating factors such as wildfire and drought** – These analyses would build on the Interior's regional Climate Science Centers' 2015 work on past trends and future projections of drought, and their impacts on State Wildlife Action Plans, giving land managers a more complete view of their management activities' effects during dry periods. These inputs would also give land managers an integrative view of climate change mitigation and adaptation options for specific ecosystems.
3. **Regular updates with national data and new management scenarios** – In support of the Priority Agenda's call to combine survey- and satellite-based data, the tool would receive regular remote sensing-based updates based on annual analysis of Landsat science products such as the National Land Cover Database and maps of burned area extent and surface water extent.
4. **On-demand analyses of land managers' specific management decisions and anticipated activities on Federal lands** – These analyses would be based on ongoing pilot studies with the FWS, in which both agencies are jointly assessing the effects of land management practices on NWR stakeholders' priority ecosystem services. (In 2014, the first pilot studies revealed diverse stakeholder values for services such as waterfowl viewing, water quality, carbon storage, and historical value.)

Interior and the U.S. Department of Agriculture (USDA) share many resource management challenges and opportunities, and manage many acres of adjoining lands. Both Departments seek to collaborate on inventorying and monitoring carbon stocks, supporting routine annual updates, developing policies for carbon management on both Departments' lands, and developing mutually reinforcing carbon management and landscape resilience approaches with managers of non-Federal lands. In 2016, working with the USDA, the USGS would integrate the USDA's expertise in the economic drivers of land conversion and short-term predictions for agricultural and forest lands, with USGS expertise in long-term land and climate change, satellite-based assessment of land characteristics, and non-market drivers of change. The collaboration would support the development of varied long-term management scenarios incorporating a range of policies and climate conditions. This would increase the capacity of both Departments' land management bureaus to assess the impacts of potential actions on carbon sequestration, and improve the characterization of uncertainties.

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Activity: Climate and Land Use Change
Subactivity: Land Use Change
Program Element: Land Remote Sensing Program

2014 Actual: $ 67.9 million (141 FTE)
2015 Enacted: $ 67.9 million (141 FTE)
2016 Request: $ 97.5 million (143 FTE)

Overview

The Land Remote Sensing (LRS) Program (*remotesensing.usgs.gov*) collects, interprets, and provides the Nation land-surface information using data acquired by satellite and airborne instruments. These data are provided under a free and open access policy via the Internet (*http://eros.usgs.gov/find-data*). The LRS Program data help scientists understand the dynamics of land use change and climate change and support efficient water resource management, agricultural crop monitoring and forecasting, forest health and wildfire recovery monitoring, and disaster management. The LRS Program provides a comprehensive, permanent, and impartial record of the planet's land surface through the National Satellite Land Remote Sensing Data Archive and aerial photography archives at the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center in Sioux Falls, SD. These archives currently contain more than 12,000 terabytes of information. The LRS Program is also developing a capability to systematically collect and analyze users' needs for Earth observation data. This analysis will help the LRS Program prioritize its product and service offerings and inform planning for future satellite designs and investments.

The LRS Program also supports research and applications that use remotely sensed data to detect, characterize and monitor changes to the Earth's land surface, land cover, and inland and coastal waters. In addition, the LRS Program provides Federal civil agencies with access to classified Earth observation data and supports the development of unclassified information products derived from such data through the National Civil Applications Program (NCAP)/Civil Applications Committee (CAC). Finally, the LRS Program continues to lead the operational testing and evaluation of unmanned aircraft systems (UAS) technology in support of many of the Department of the Interior's activities.

Since 1972, Landsat satellites have provided the only continuous, authoritative global record of changes to the Earth's land surface at a scale allowing the differentiation between natural and human-induced change. Under the Land Remote Sensing Policy Act of 1992, and associated Presidential Decision Directives, Interior and the USGS share responsibility for Landsat program management with NASA. Within this successful partnership, NASA develops and launches Landsat satellites while the USGS develops the associated ground systems and, following launch and on-orbit checkout by NASA, assumes ownership and operation of the satellites. Further, the USGS manages and maintains the data stream produced by the Landsat satellites and makes data products available to support decisionmakers.

In 2013, the USGS released a report on "The Users, Uses, and Value of Landsat Satellite Imagery – Results from the 2012 Survey of Users" (*http://pubs.usgs.gov/of/2013/1269/*). Responses from over 11,000 current users of Landsat data indicate an ongoing and increasing demand for Landsat imagery, and the report provides a conservative estimate of Landsat's annual economic benefits within the United States at approximately two billion dollars, far above the multi-year cost to design, build and launch any two Landsat satellites. Also in 2013, the National Research Council released a report, "Landsat and Beyond: Sustaining and Enhancing the Nation's Land Imaging Program" (*http://www.nap.edu/catalog/18420/landsat-and-beyond-sustaining-and-enhancing-the-nations-land-imaging*), which makes a strong case for sustained land-imaging satellite operations in order to ensure continuation of the Landsat data stream.

In 2014, the National Science and Technology Council released a "National Plan for Civil Earth Observations" (*http://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/national_plan_for_civil_earth_observations_-_july_2014.pdf*). In preparation for the plan, a governmentwide task force conducted a comprehensive assessment of 362 space, airborne, terrestrial (including fresh water), and marine Earth observation systems. Each was ranked for its impact on 13 societal benefit themes. Of the 362 Earth observing systems examined, Landsat ranked third highest overall and second among all satellite systems, behind only GPS. The report also recommended, "The NASA Administrator, together with the Secretary of the Interior through the Director of USGS, will implement a 25-year program of sustained land-imaging for routine monitoring of land-cover characteristics, naturally occurring and human-induced land-cover change, and water resources, among other uses. They will also ensure that future land-imaging data will be fully compatible with the 42-year record of Landsat observations." As detailed below, this recommendation is in line with the Administration's plans.

Program Performance

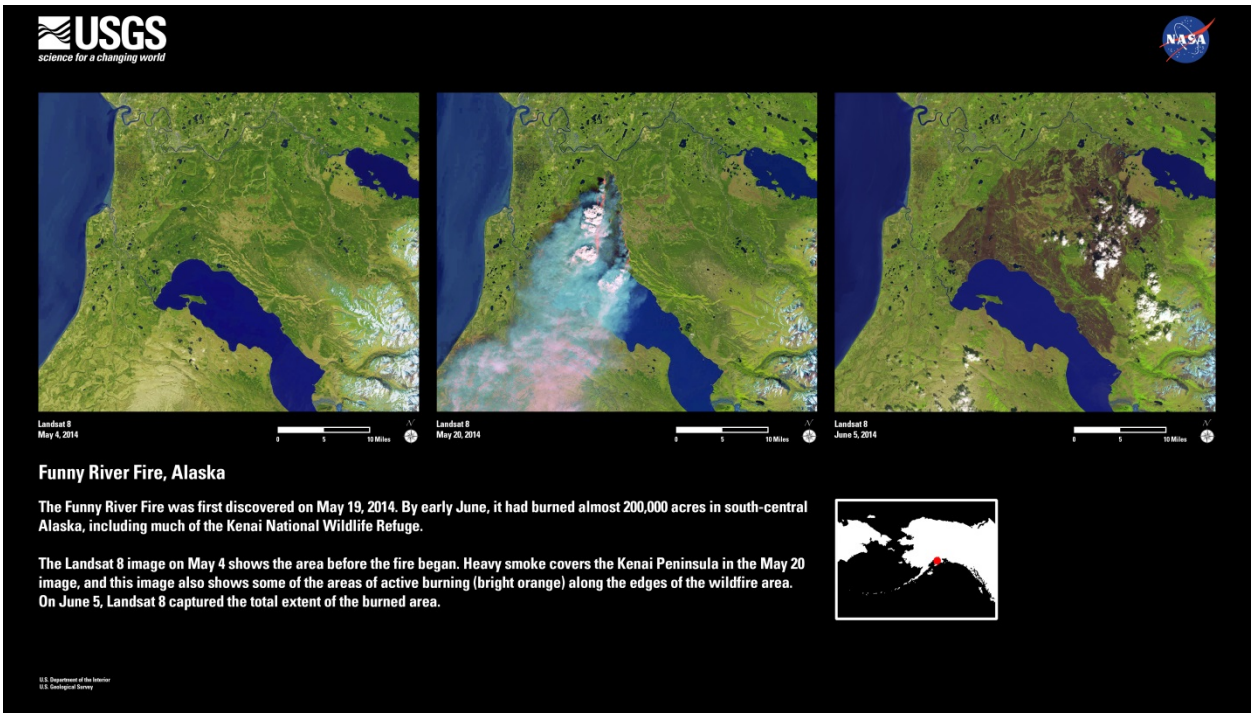
Landsat Satellite Missions – The USGS continues to conduct flight operations for Landsat 7 and Landsat 8. Under routine operations of these missions, the USGS collects more than 1,000 scenes per day (12,000 square miles per scene) of spectral information ranging from visible to near infrared to shortwave infrared to thermal infrared data for any location on the Earth's land surface every eight days. Landsat 7, launched in 1999, continues to collect valuable data, though with significant data gaps in each scene due to an equipment failure in 2003. Now more than a decade beyond its design life and operating on back-up systems, Landsat 7 has enough fuel to maintain its orbit into 2019. Landsat 8, launched in 2013, has an estimated five-year design life (to 2018) for the satellite and its primary sensor, and a three-year design life (to 2016) for its thermal sensor (a key tool used for water management).

In 2014, the National Aeronautics and Space Administration (NASA) addressed congressional and Administration directives to devise an aerospace architecture designed to ensure 25 years of sustainable land imaging that will provide data compatible with the past 42 years of Landsat data. As a major part of this effort, a NASA/USGS Sustainable Land Imaging (SLI) Architecture Study Team (AST) examined numerous long-term alternatives, in consultation with the Landsat Science Team, an advisory group representing the Landsat science and applications communities. The budgets of both the USGS and NASA provide funding to sustain the Landsat data stream, which is critical to understanding global

landscapes. The Landsat satellite program is funded at $77.6 million, $24.3 million above 2015, and includes funding for the maintenance and operation of ground systems and satellite operations. The successful launch of the Landsat 8 satellite in 2013 enables the continuation of the 42-year Landsat record. Following extensive study, the Administration has established a plan for a long-term Sustainable Land Imaging program that would extend the four-decade long Landsat series of measurements of the Earth's land surfaces for another two decades. The plan includes three simultaneous activities. The first is the initiation of a new U.S.-built small satellite with a thermal imager that would launch as soon as feasible, likely in 2019, and would operate either in conjunction with a European Sentinel-2 satellite or with the Landsat 8. The second activity would be the initiation of Landsat 9 as a rebuild of Landsat 8, with a target launch date in early 2023. The third activity is ongoing investment in technology development and systems innovation to reduce risk in next generation missions, including Landsat 10.

In 2016, the USGS will work with NASA to support the Administration's plan for a Sustainable Land Imaging Program. The USGS is requesting $24.3 million to develop systems to operate the satellites and collect, archive, process, and distribute the data for the program. The requested funding increase in 2016 is the first time the USGS will be requesting new funding to build capacity to operate the satellites and collect, archive, process and distribute the data for the SLI program. The requested funding increase would document the space and ground segment requirements and define specifications for instrument procurements, provide engineering support and technical assistance in the evaluation and selection of NASA's spacecraft, and in evaluating competitive contract proposals for needed functionality. In order to maximize thermal imager small satellite and Landsat 8 Rebuild ground system development, implementation, and operational cost efficiencies, it is critical that the USGS actively participate in the NASA space system formulation and acquisition activities. During 2016, the USGS would support NASA mission systems engineering activities, including: space-to-ground interface design, mission operations concept establishment, system component integration definition, development of verification plans for system testing, instrument calibration and validation engineering, support of instrument specifications and requirements definition, and building and evaluating requests for proposals. Finally, the USGS would develop and refine ground-system operations concepts and requirements, perform ground system design activities with an emphasis on the space-to-ground interface, and formulate acquisition strategies for ground network, data processing, and mission operations center (flight systems and software) capabilities.

Additionally in 2016, the USGS would need to establish the capability to acquire, store, and disseminate data from the European Space Agency's Sentinel-2 satellites (Sentinel 2A is expected to launch in 2015 and Sentinel 2B in 2016). Sentinel-2 data may partially mitigate the risk of losing the eight-day revisit coverage during the period between the decommissioning of Landsat 7 and the launch and operations of a Landsat 8 Rebuild mission. In addition, Sentinel-2 data would augment Landsat data, increasing the possible revisit over any one spot on the Earth's surface to just three days, as long as two Sentinel-2s and two Landsats are in orbit at the same time. This frequency of revisit will help USGS satisfy the increasing demand for rapid revisit required by operational applications like global crop monitoring and the monitoring of natural resources and features such as forests, sea ice, snow cover, and surface water.



Data Management Operations – Land remote sensing data acquired by the USGS and its government, commercial, and foreign partners are managed and archived at the EROS Center. The EROS Center has the ongoing challenge of managing and distributing a massive volume of stored data, while efficiently processing and making available large volumes of new data ingested daily from two Landsat satellites and other Earth observation systems. In 2014, the LRS Program disseminated 129 terabytes of land remote sensing data products, free of charge, via the Internet. These free downloads involved over 1.16 million data files from over 300 data sets hosted on the USGS EarthExplorer data portal (*http://earthexplorer.usgs.gov*). In addition to 5.5 million Landsat images, the archive holds 2.6 million global images of current and historical data from several other satellite systems. Following the President's commitment at the United Nations to provide assistance for global efforts to combat climate change, the LRS Program, in cooperation with the National Geospatial-Intelligence Agency (NGA), has made improved global topographic data publically available via the EarthExplorer portal *(http://earthexplorer.usgs.gov/)*. The broad availability of more detailed elevation data across the globe through the Shuttle Radar Topography Mission (SRTM) will improve baseline information that is crucial to investigating the impacts of climate change on specific regions and communities. Prior to the release of this data, only global coverage at 90-meter resolution was available. Since September of 2014, 30-meter data for Africa, North and South America, Pacific Islands, and northern Europe have been released through the EROS Center, with more areas to follow in 2015. The EROS archive also provides over 6.5 million aerial photos of the United States and its territories. In 2016, the LRS Program will continue to disseminate millions of land remote sensing data products.

The USGS continues its leadership role in remote sensing science and technology by providing global remote sensing datasets and information products in support of a broad spectrum of societal benefits. The USGS supports international Earth observation efforts through the International Committee on Earth

Observation Satellites, the Group on Earth Observations, the U.S. Group on Earth Observations, and through the International Charter on Space and Major Disasters, which provides disaster response remote sensing data free of charge to any country requesting assistance. The USGS responds to disasters on behalf of various government agencies; this response consists of coordination of satellite data acquisition, Web-based mapping services, data dissemination and delivery, and post-disaster data accessibility.

Product Improvement – In 2014 and 2015, the LRS Program expanded its work with intramural and extramural scientists to develop the Landsat-based remote sensing science required for new value-added data products. These new products will support improved natural resource management decisions in both the public and private sectors. In 2016, the LRS Program will continue work to increase the usability of Landsat and other remote sensing datasets, advancing the science, usability, and centralized sharing of Landsat data applications and software. A key program goal in 2016 is to operationally produce Landsat-based science products to be updated every eight days for the United States, including surface temperature, fire disturbance, snow covered area, and green biomass. These datasets will support both natural resource managers and the climate monitoring community. The Landsat Advisory Group (LAG), a working group of the National Geospatial Program's Federal Advisory Committee (*www.fgdc.gov/ngac*), is providing recommendations on directions for those activities. In 2013, the LAG recommended that the LRS Program modify its current digital land-image products to make them more useful for commercial, value-added information providers and other customers who wish to extract maximum value from the imagery. In 2016, the LRS Program will continue work begun in 2014 and 2015 to address LAG recommendations regarding simplifying access to the standard Landsat product and investigating ways to enable portions of the large-area, large-file sized Landsat scenes to be selected by the user and downloaded, refining the ground-area measurement accuracy of Landsat products to improve detection of changing conditions on the land surface, and improving co-registration of same-area Landsat scenes obtained on different dates.

Filling a critical gap in drought monitoring: *The USGS is developing an operational agricultural drought-monitoring tool, called the Quick Drought Response Index (QuickDRI), to detect short-term changes and rapid intensification of drought conditions through the integration of satellite, climate, and biophysical information. In collaboration with NASA, the U.S. Department of Agriculture, National Oceanic and Atmospheric Administration, the National Weather Service, and the National Drought Mitigation Center, QuickDRI information will be used to determine and respond to rapidly changing drought situations through coordination with National, regional and State early warning systems.*

Science Support to Decisionmakers – Consistent global measurements are necessary to advance understanding of the Earth's changing land surface and climate. Satellite observations are often the most efficient and cost-effective means to address these information needs. For example, the Land Change Science Program relies heavily on Landsat for the ability to collect data for every ecosystem in the United States, and to monitor, update and detect change over time; it uses this data to produce the National Land Cover Database, to estimate biological stocks of carbon in vegetation and shallow soils, and to map ecosystems. In 2014 and 2015, the LRS Program began developing Landsat-based products to serve as Climate Data Records (CDRs) and related Essential Climate Variables (ECVs). The CDRs are long-term time-series measurements (surface reflectance, surface temperature) that support the development of ECVs such as snow covered area, land cover, biomass, and measures of wildfire disturbance such as burned area extent. The CDRs and ECVs provide an authoritative, impartial basis for regional to continental scale identification of historical change,

monitoring of current conditions, and prediction of future conditions. In 2014, the LRS Program updated its first CDR, a surface reflectance product based on data from the Landsat 8 Operational Land Imager. This product reduces the processing time and increases accuracy for all users and supports development of higher-order products such as surface water extent and wildfire burned area extent. In 2014, over 1.3 million surface reflectance products (116 terabytes) were distributed from the EROS Center.

In 2015, the LRS Program capitalized on the unique characteristics and long-term continuity of Landsat observations to generate one provisional CDR, a land surface temperature product, and three ECV products useful to both natural resource managers and the climate monitoring community (burned area extent, surface water extent, and snow-covered area). In 2016, the USGS will refine its products for public release in consistent, user-friendly forms via online interfaces. The LRS Program is also developing decision-support tools related to drought monitoring and global irrigation for agriculture, and is investigating emerging applications in Lidar and hyperspectral technologies.

The LRS Program will continue to work with the Landsat Science Team to develop Landsat applications that support natural resource management in critical sectors of the Nation's economy. For example, water resources managers in at least 12 states are using a Landsat-based tool (developed through Landsat Science Team partnerships at the University of Idaho and the Idaho Department of Water Resources) for water management and impartial, data-driven adjudication of water rights. The tool uses Landsat optical and thermal data to produce water-consumption maps of irrigated fields more efficiently than using traditional field-based methods.

In 2014, a University of Maryland-led, multi-organizational team released to the public a database showing global forest gain and loss from 2000 to 2012; more than 650,000 Landsat images were processed to derive the final characterization of forest extent and change. In 2015, the validation of the global percent tree cover, percent barren and percent surface water for the year 2010 will be completed and the data will be released to the public.

As the recipient of a multi-year competitive award under the LRS Program, AmericaView (*www.americaview.org*) is a nationwide university-led consortium of remote sensing scientists who support the use of Landsat and other public domain remote sensing satellite data through applied remote sensing research, K-12 and higher STEM education, workforce development and technology transfer. In 2016, AmericaView will focus on remote sensing high impact projects with the 40 participating States including activities such as enhancing Landsat data retrieval and delivery through expanded local nodes, expanding undergraduate online remote sensing courses, and introducing students to remote sensing by showcasing the Landsat mission and the many uses of satellite imagery in addressing some of today's most challenging society and environmental issues.

Unmanned Aircraft Systems (UAS) Applications – On behalf of Interior and its bureaus, the LRS Program continues to lead the operational testing and evaluations that have demonstrated that UAS technology can be used to support many of the Department's activities (*http://uas.usgs.gov/*). UAS technology, typified by relatively small, remotely controlled aircraft capable of carrying various types of miniaturized land-imaging sensors, can enable increased monitoring of Earth surface processes (erosion mapping, forest health conditions, wildfires, earthquake zones, invasive species, etc.) in areas difficult to

access, and at lower human risk and potentially lower cost than traditional methods using piloted aircraft or ground exploration methods. All Interior UAS missions are flown in full compliance with Federal laws and Department policies and procedures, which include operating flights primarily over Interior lands and obtaining written permission from landowners if flights operate over private lands. Working with Interior and through partnerships with the National Oceanic and Atmospheric Administration (NOAA), NASA, and others, the USGS has completed numerous proof-of-concept missions to determine this technology's utility in meeting Interior's current Earth observation requirements.

In 2014 and 2015, the LRS Program investigated next-generation UAS capabilities and potential commercial sources for UAS-acquired data. The LRS Program also participated in interagency policy activities to support the transition of the UAS from limited-permit research flights to Federal Aviation Administration-approved operations, lowering a barrier to Interior bureaus' use of the UAS. In 2015, the LRS Program also developed a strategic plan and performed a pilot study on how UAS datasets can be made available over the Internet to the USGS and the Interior science community. This was the first step toward the goal of integrating these data with other geospatial datasets in order to satisfy unique remote sensing applications.

In 2016, the LRS Program will continue to seek operational test and evaluation partnerships with Interior bureaus, NOAA, NASA, Department of Defense, and others to leverage missions and share technology. The LRS Program will also continue to coordinate with Interior and its bureaus to develop a plan for implementing UAS technology, data, and services and will complete a USGS UAS Road Map as a foundation for future investments in support of USGS requirements. The LRS Program will also investigate new UAS sensors, such as hyperspectral and lidar, and will acquire test datasets to support scientific investigations.

Civil Applications Projects – Data from classified systems and commercial satellites are used to investigate climate change and other Earth dynamics, ecosystems, natural hazards, manmade disasters such as wildfires, and to improve land and resources management. This activity is managed through the National Civil Applications Project (NCAP). In 2014, the NCAP provided support and data for landslides mitigation in both Washington and Colorado, wildfire suppression efforts in the Rocky Mountain and Western United States, and damage assessment from natural hazards. The NCAP also tasked collection during 2014 for post-scientific analysis of the Oso landslide and the South Napa earthquake.

A Presidential Directive established the Civil Applications Committee (CAC) on October 3, 1975. Interior was charged with forming and chairing a coordinating and oversight committee, and delegated the role of chairing the CAC to the USGS. The 2010 National Space Policy specifies that Interior/USGS has the role to provide environmental and disaster remote sensing information acquired from national security space systems to civil government agencies.

In 2016, the USGS will maintain its civil science leadership of the CAC and assess ways to more effectively use classified assets for hazards, environmental, and natural resources applications.
In 2016, the NCAP plans to continue publishing peer reviewed research results in two NGA classified journals. There are also plans to increase collaboration and support to the USGS Earthquake Hazards Program, as well as increased work with USGS hydrologists working to identify groundwater monitoring

well locations. The acquisition, archive, and dissemination of classified remotely sensed data to support science programs will be continued. Support for the Volcano Hazard Program and Volcano Disaster Assistance Program will be continued. The NCAP Global Fiducials Project will continue to collect high-resolution images of environmentally sensitive sites for use by cooperating scientists documenting Earth's surface processes and change.

Activity: Climate and Land Use Change
Subactivity: Land Use Change
Program Element: Land Change Science

2014 Actual: $10.5 million (53 FTE)
2015 Enacted: $10.5 million (51 FTE)
2016 Requested: $11.7 million (56 FTE)

Overview

The goal of the Land Change Science (LCS) Program is to understand the Nation's most pressing environmental, natural resource, and economic challenges by providing the information and tools necessary for identifying possible solutions to these challenges. The LCS Program conducts research on land cover, which provides a historical record of resource use and indicates the availability and quality of natural resources; assessing the impacts of land cover change; and by developing tools for decisionmakers to use for resource allocation decisions. Comprehensive land cover information is essential in a wide variety of investigations, such as assessing the impacts of climate change, evaluating ecosystem status and health, understanding spatial patterns of biodiversity, and informing land use planning. The LCS Program's research activities include understanding of:

- Environmental consequences of land change and its impacts on people, environment, economy, and resources
- Ecosystem functioning and the services delivered by these functions
- Improving the scientific basis for vulnerability and risk assessments, as well as disaster mitigation, response, and recovery

The LCS Program manages the creation, updates, and distribution of the National Land Cover Database (NLCD), *(http://www.mrlc.gov/)*, which is the standard land cover map of the Nation. The NLCD provides valuable information on the types of land cover, changes that are occurring, their distribution, and patterns, and the potential consequences of these changes. Land cover information is critical for identifying and assessing climatic changes since surface energy fluxes between the land and the atmosphere have a major impact on climate. This information is also essential in assessing water quality and quantity, biodiversity conservation efforts, and the risks from natural hazards.

The LCS Program's activities utilize land cover information, remote sensing data, land change models, sensitivity analyses, and the probabilities of specific landscape disturbances, to develop tools so that land and community managers can make knowledgeable resource allocation decisions and assess the impacts of natural hazard events. These projects include developing case studies, interpretative assessments, and workshops involving stakeholders, and other partners in collaborative decisionmaking processes.

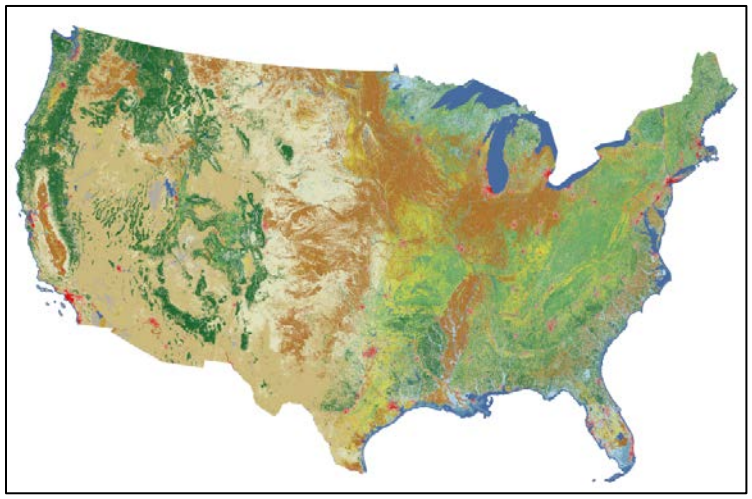
The LCS Program collaborates with other USGS programs, and contributes to bureau initiatives, including the Science Application for Risk Reduction (SAFRR), LANDFIRE, WaterSMART,

Chesapeake Bay restoration effort, and the New Energy Frontier. The program also supports the research objectives of the U.S. Global Change Research Program and is an active participant in international science initiatives through the promotion and use of USGS science results and assets around the globe.

Program Performance

Land Cover Monitoring and Assessments – The LCS Program studies land use and land cover change at multiple scales, documenting the geographic variability of change and defining the environmental, social, technological, and political drivers of change, as well as assessing the impacts of these changes. Current land cover monitoring activities include the NLCD and regional activities in areas such as the Great Plains, Rocky Mountains and the Chesapeake Bay watershed. Regional assessments involve analyzing the impacts of land cover change on water quality, biodiversity and community risk and vulnerability, as well as conducting land cover change modeling, used to assess impacts of future resource use and climate change.

NLCD – In 2014, the mapping of the 2011 iteration of the conterminous NLCD was completed, utilizing Landsat images acquired in 2011. In 2015, the State of Alaska will be added and the accuracy assessment of the 2011 NLCD will be conducted. Also in 2015, planning will be conducted for the 2016 iteration, which will be the first one to utilize data from Landsat 8, which will entail an assessment of the differences between data acquired by that satellite and Landsat 7. In addition, planning will be conducted on transitioning the NLCD from a five-year update cycle to an annual update.



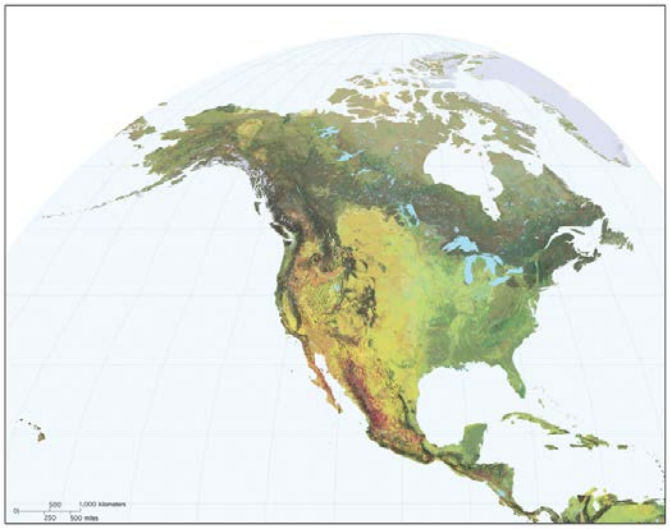
2011 National Land Cover Database

Land Cover Modeling – Information on future land use and land cover (LULC) change is needed to analyze the impacts of change on ecological processes. In 2014, the LCS Program produced spatially explicit, thematically detailed LULC projections for the conterminous United States. Four qualitative and quantitative scenarios of change were developed, with characteristics consistent with the Intergovernmental Panel on Climate Change (IPCC) Special Report on 5 Emission Scenarios (SRES). Four spatially explicit datasets consistent with scenario storylines were produced for the conterminous United States, with annual LULC maps from 1992 through 2100. The future projections are characterized

by a loss of natural land covers in most scenarios, with corresponding expansion of anthropogenic land uses. In 2015 and 2016, the LULC projections will be used to analyze their interactions with the atmosphere, which drive both water and energy fluxes. This will allow atmospheric modelers to conduct holistic estimates of future weather and climate. In addition, the LULC projections will be used to assess their impacts on hydrologic processes, allowing researchers to determine potential future hydrologic regimes under multiple potential land cover scenarios. Understanding potential future hydrologic processes enables future management of water resources and facilitates analyses of flood risk and water-quality issues.

Conducting Ecosystem Services Assessment and Valuation – The LCS Program develops spatially-explicit models of ecosystem extent and functioning, as well as analyzing the services provided by these ecosystems, including carbon sequestration, water availability, and biodiversity conservation. Critical research components include mapping ecosystems, assessing invasive species and valuing the services produced by ecosystems. In 2014, LCS researchers assessed the role of grassland ecosystems in subsistence agriculture and the global carbon cycle. Researchers estimated the spatial and temporal patterns of the global grassland biomass and analyzed their driving forces using field measurements, and satellite data. The dynamics of regional grassland biomass showed trends were largely determined by regional climate variability, disturbances (i.e., fire), and management practices (such as grazing for meat production). The methods and results from this study can be used to monitor the dynamics of grassland biomass and evaluate grassland susceptibility to climate variability and change, disturbances, and land uses. Increases in the 2016 budget would be used to assess ecosystem services in critical landscapes and water resource availability. The LCS Program proposes to develop methodologies for the assessment and mapping of ecosystem goods and services, with an emphasis on understanding how they respond to changing landscape and climatic conditions. These tools would translate knowledge gained through a variety of case studies into standardized thematic models, and tools that facilitate improved decisionmaking by natural resource managers. The Program also proposes to detect and map otherwise undocumented surface water features that have either artificially been built or naturally store water (i.e., act like reservoirs). Given estimates of over three million artificial impoundments in the country, this work will be very important in improving estimates of the total amount of water in watersheds.

Ecosystem Mapping – In 2014, in cooperation with the ESRI Corporation, the LCS Program developed a global ecosystem map, with land surface elements characterized through an ecophysiographic stratification of the planet (*http://rmgsc.cr.usgs.gov/ecosystems/docs/AAG_Global_Ecosystems_Booklet.pdf*). The stratification produced 3,923 terrestrial ecological land units (ELUs) at a base resolution of 250 meters. This subdivision of the Earth's surface into relatively fine, ecological land areas is designed to be useful for various types of ecosystem research and management applications, including assessments of climate change impacts on biodiversity, economic and non-economic valuation of ecosystem services, and conservation planning. In 2015 and 2016, this product will be used to assess the impacts of climate change on ecosystem services and a similar product will be created for marine ecosystems.



Ecological Land Units of North and Central America

Invasive Species – Eruptive mountain pine beetle (Dendroctonus ponderosae, MPB) populations have caused widespread mortality of pines throughout western North America since the late 1990s. In 2014, LCS researchers evaluated the susceptibility of both ponderosa and lodgepole pine trees to successful MPB colonization in the Front Range of Colorado. Results suggest that, in contrast to previous reports, ponderosa and lodgepole pine were equally susceptible to MPB infestation during the study period. This suggests that forest managers may anticipate similar impacts in both hosts during similar environmental conditions when epidemic-level MPB populations are active in mixed-pine stands. Future work will involve using this data to assess the impacts of climate change on insect infestations and their impacts on wildfires and the carbon cycle.

Impacts of Renewable Energy Projects – Recent policy and economic conditions have encouraged a renewed interest in developing large-scale solar projects in the Southwest United States. In addition to the quality of the solar resource, solar developers must take into consideration many environmental, social, and economic factors when evaluating a potential site. In 2014, LCS researchers described a proof-of-concept, Web-based Geographical Information Systems (GIS) tool that evaluates multiple user-defined criteria in an optimization algorithm to inform discussions and decisions regarding the locations of utility-scale solar projects. In 2015 and 2016, LCS researchers will perform BLM's Rapid Ecoregional Assessment for the Wyoming Basin, which will develop regional geospatial analytical methods to forecast climate and energy-driven land use change.

Assessing Societal Vulnerability to Natural Hazards – This research utilizes models, sensitivity analyses, and geographic distributions of people and infrastructure along with the probability of specific disturbance factors, to evaluate a community's vulnerability and risk. The LCS Program helps local and State governments assess their vulnerability by augmenting the USGS's traditional expertise in natural hazards with the ability to assess the exposure, sensitivity, and resilience of a community. These projects include case studies, interpretative assessments, and science impact studies involving stakeholders and other partners in collaborative processes. Increases in the 2016 budget would be used to assess the impacts of sea-level rise and storm surges on coastal infrastructure and developing a mechanism to

rapidly create disaster scenarios. The LCS Program proposes to assess the impacts of coastal land use change on community risk and vulnerability to sea-level rise and storm surges. The objective of this project is to develop methods to characterize and communicate the vulnerability of coastal communities. In addition, to prepare for the impacts of hazards before they strike, LCS researchers would develop fully realized scenarios of disaster events in collaboration with Federal, State, local and university partners. These scenarios would apply integrated science across multiple mission areas at the intersection of community decision making and emergency response.

Population Exposure to Earthquakes – Earthquake scenario-based, loss-estimation studies are useful for gaging potential societal impacts from earthquakes but can be challenging to undertake in areas with multiple scenarios and jurisdictions. In 2014, using 20 earthquake scenarios developed for the State of Washington (USA), LCS researchers demonstrated how a population-exposure analysis across multiple jurisdictions helps emergency managers understand and communicate where potential loss of life may be concentrated and where impacts may be more related to quality-of-life issues. Results indicate that certain well-known scenarios may directly impact the greatest number of people, whereas other, potentially lesser-known, scenarios impact fewer people but have more severe consequences. The use of economic data to profile each jurisdiction's workforce in earthquake hazard zones also provides additional insight on at-risk populations. This approach can serve as a first step in understanding societal impacts of earthquakes and helping practitioners to efficiently use their limited risk-reduction resources. In 2015 and 2016, these results will be used in a multi-hazard scenario assessment for Washington State that will add the threats posed by volcanoes and tsunamis.

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Energy, Minerals, and Environmental Health

Activity: Energy, Minerals, and Environmental Health

				2016				
		2014 Actual	2015 Enacted	Fixed Costs and Related Changes (+/-)*	Internal Transfer	Program Changes	Budget Request	Change from 2015 (+/-)
Mineral and Energy Resources								
Mineral Resources ($000)		45,931	45,931	787	0	999	47,717	1,786
	FTE	291	291	0	0	14	305	14
Energy Resources ($000)		25,970	24,895	348	0	2,825	28,068	3,173
	FTE	140	140	0	0	9	149	9
Subtotal: Resources		**71,901**	**70,826**	**1,135**	**0**	**3,824**	**75,785**	**4,959**
	FTE	**431**	**431**	**0**	**0**	**23**	**454**	**23**
Environmental Health								
Contaminant Biology ($000)		9,647	10,197	150	0	1,723	12,070	1,873
	FTE	54	57	0	0	6	63	6
Toxic Substances Hydrology ($000)		9,967	11,248	149	0	4,050	15,447	4,199
	FTE	55	61	0	0	17	78	17
Subtotal: Environmental Health		**19,614**	**21,445**	**299**	**0**	**5,773**	**27,517**	**6,072**
	FTE	**109**	***118***	***0***	***0***	***23***	***141***	***23***
Total Requirements ($000)		**91,515**	**92,271**	**1,434**	**0**	**9,597**	**103,302**	**11,031**
	Total FTE	**540**	***549***	***0***	***0***	***46***	***595***	***46***

**Fixed Costs are $1,270 and Seasonal Federal Health Benefits are $164*

Summary of Program Changes

Request Component	($000)	FTE	Page
Mineral Resources	**999**	**14**	
Critical Minerals	2,440	14	C-75
R&D to Address Environmental Impacts of Minerals Development	559	0	C-76
Sun Setting Activities	-2,000	0	C-75
Energy Resources	**2,825**	**9**	
All-of-the-Above Energy: Renewable Energy - Geothermal	200	2	C-72
Alternative Energy Permitting on Federal Lands	875	1	C-72
Ecosystem Services: Enhancing Resilience in Coastal Infrastructure	150	1	C-47
Ecosystem Services: Evaluating Green Infrastructure Investment	250	1	C-47
Unconventional Oil and Gas Research	1,550	4	C-69
ERP Pubs Contributions	-200	0	C-74
Contaminant Biology	**1,723**	**6**	
Critical Landscapes: Columbia River	50	0	C-22
Environmental Impacts of Uranium Mining	273	1	C-73
Unconventional Oil and Gas Research	1,400	5	C-70
Toxic Substance Hydrology	**4,050**	**17**	
Critical Landscapes: Columbia River	50	1	C-22
Emerging Contaminants & Chemical Mixtures	700	4	C-55
Environmental Impacts of Uranium Mining	1,750	8	C-74
Resilient Coastal Landscapes and Communities: Contaminant Network Along Northeast Coast	1,300	3	C-30
Unconventional Oil and Gas Research	250	1	C-70
Total Program Change	**9,597**	**46**	

Justification of Program Changes

The 2016 Budget Request for Energy, Minerals, and Environmental Health (EMEH) is $103,302,000 and 595 FTE, a net change of +$11,031,000 and + 46 FTE from the 2015 Enacted Budget. For more information on the EMEH Mission Area changes, please see Section C, Program Changes as referenced in the table above.

Activity Summary

In 2016, there is a proposed technical adjustment to create two subactivities within the EMEH activity: the *Mineral and Energy Resources* subactivity (comprised of the Mineral Resources Program and the Energy Resources Program), and the *Environmental Health* subactivity (comprised of the Contaminant Biology Program and the Toxic Substances Hydrology Program). For more information, please see Technical Adjustments, Section B. The *Mineral and Energy Resources* subactivity conducts research and assessments on the location, quantity, and quality of the Nation's and world's mineral and energy resources, including economic implications, and interactions of these resources with the environment (both natural and as a result of extraction) and utilization. The Environmental Health subactivity conducts research on environmental impacts of human activities that introduce chemical and pathogenic contaminants into the environment and threaten human, animal (fish and wildlife), and ecological health.

The proposed EMEH Activity would consist of four subactivities:

Mineral and Energy Resources

- Mineral Resources Program (*http://minerals.usgs.gov*)
- Energy Resources Program (*http://energy.usgs.gov*)

Environmental Health

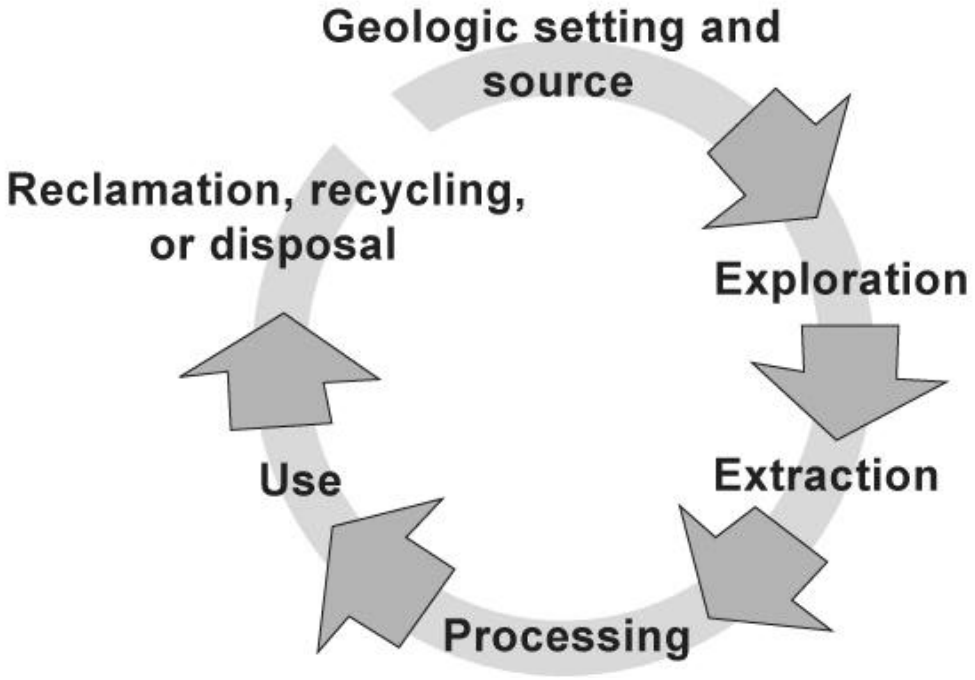
- Contaminant Biology Program (*http://www.usgs.gov/envirohealth/cbp/index.html*)
- Toxic Substances Hydrology Program (*http://toxics.usgs.gov*)

Mineral and Energy Resources

The Mineral and Energy Resources Programs conduct research on the location, quantity, and quality of the Nation's and the world's energy and mineral resources, including economic parameters and interactions of these resources with the environment, both natural and as a result of extraction and utilization. Together, these two programs provide information to resource managers, policymakers, and the public to support science-based policy development, land and resource management, and decisionmaking on a range of critical resource issues. The Mineral and Energy Resources programs provide valuable contributions in areas including: energy and mineral development and use; informing a variety of energy-mix scenarios; developing energy policy; determining mineral resource needs; understanding domestic resources and production in the context of global resource supply chains; and evaluating trade-offs, including environmental risks. The Mission Area provides impartial, trusted science and information for understanding both the occurrence and distribution of national and global energy and mineral resources.

In 2013, the USGS published an Energy and Minerals Science Strategy which summarizes national science priorities that the USGS is best suited to address, and serves as a strategic framework for USGS Energy and Minerals science goals, actions, and outcomes for the next decade. This plan describes the USGS role and important partnership opportunities, and outlines steps to take in the next 10 years to continue to provide the Nation with energy and minerals science and information on both current and emerging issues. The Energy and Minerals Science Strategy provides a framework of complete life cycle

analysis (see figure below) upon which to build and expand current work for understanding trade-offs. The framework also informs decisionmaking with respect to such issues as economic vitality, environmental health, national security, and responsible resource management and protection on U.S. Department of the Interior (Interior) and other lands.



Conceptual diagram that depicts a resource lifecycle for energy and minerals. Society faces key decisions within each stage of the resource lifecycle. Scientific understanding is essential to providing information for these decisions.

Each time the Energy Resources Program develops a new assessment methodology, an external panel of technical experts formally reviews the methodology and approach. The methodology is revised based on the review and is not considered final until it has received expert review and revision. Recently, external experts reviewed the following methodologies:

- Estimate carbon sequestration potential for uniform application to geologic formations across the Unites States.
- Assess reserve growth in oil and gas fields. (Assessment of both undiscovered resources and additions to reserves from discovered fields and reservoirs requires estimation of reserve growth.).
- Determine economically recoverable resources of unconventional petroleum resources (coalbed methane, tight gas sands, shale gas, and shale oil).

Other methodologies, as they are developed and as the draft approach is finalized, will be reviewed in 2015 and 2016.

Using guidance developed by the National Academy of Sciences Committee on Critical Minerals published in 2008, the Mineral Resources Program identified 16 mineral commodities as the focus of the

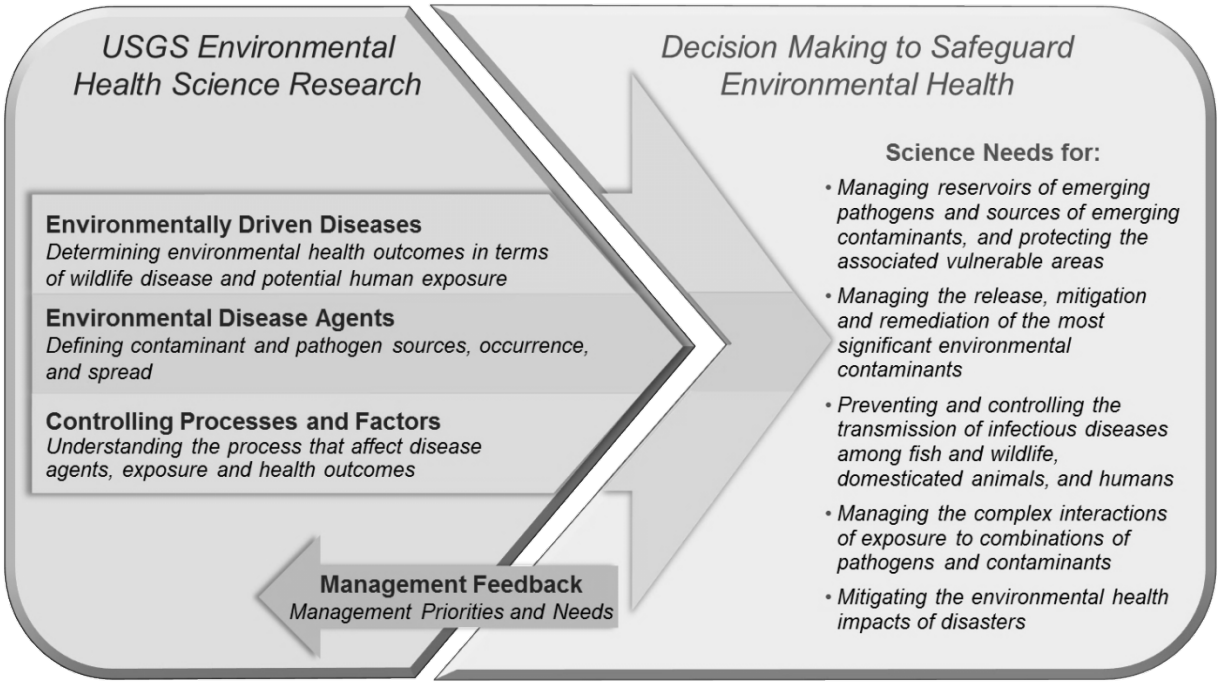
next National Mineral Resource Assessment. These commodities include metals and rare earth elements needed for new energy and "green" technology development and industrial minerals important to agriculture. The USGS conducted a Mineral Resource Assessment Forum in 2012 to examine methodologies for producing mineral assessments and to determine the science needed to produce the most relevant and useful assessments in anticipation of starting the next National Assessment. New mineral deposit and mineral environmental model development for critical commodities continued in 2012 and deposit models were completed in 2013.

The Mineral and Energy Resources Program continues to increase focus on integrating its core capabilities more broadly. The programs are jointly developing approaches to natural resource assessments that incorporate mineral and energy resource information, as well as environmental and economic information. Several pilot projects, including a uranium study, are in the early stages of implementation. These projects will help decisionmakers consider a more comprehensive set of trade-offs for the increasingly complex set of conflicting and competing resource needs the Nation faces.

Environmental Health

The Contaminant Biology and Toxic Substances Hydrology Programs conduct research on the environmental impacts of chemical and pathogenic contaminants that enter the environment through natural and anthropogenic mechanisms, and threaten human health and the health of the Nation’s environment, including fish and wildlife populations. In 2013, the USGS published its first Environmental Health Science Strategy, which summarizes national environmental health priorities that will serve as a strategic framework for USGS environmental health science goals, coordination of research efforts, partnerships, and outcomes for the next decade. This strategy delineates the connection between USGS scientific research and its ability to support decisionmaking to safeguard environmental health.

The USGS is a lead Federal agency in providing information and tools to address occurrence, behavior, and effects of environmental contaminants, including impacts on susceptible ecosystems and implications for human, wildlife, and fish health. This information includes identifying chemical and pathogenic environmental contaminants (pesticides, surfactants, human and veterinary pharmaceuticals, and other industrial and naturally occurring contaminants); developing methods to identify sources of environmental contamination and measuring those contaminants in habitats and biota; assessing toxicological significance of contaminant exposure to vulnerable organisms; characterizing effects on organisms exposed in susceptible environmental settings, including potential human exposure; and providing information on performance of best management practices and treatment alternatives. This informs decisionmaking by the public and industry and helps resource managers and policymakers to assess environmental risks; prevent contamination; license and approve chemicals; and manage, protect, and restore natural resources, contaminated lands, and important natural ecosystems, including Trust resources of the Interior. These efforts complement other USGS programs by focusing on new and currently understudied issues and contaminants, and by developing and improving methods to detect and characterize toxic substances in the environment.



The USGS role in environmental health science is providing scientific information and tools to environmental, natural resource, agricultural, and wildlife, and public health management agencies for management and policy decisionmaking.

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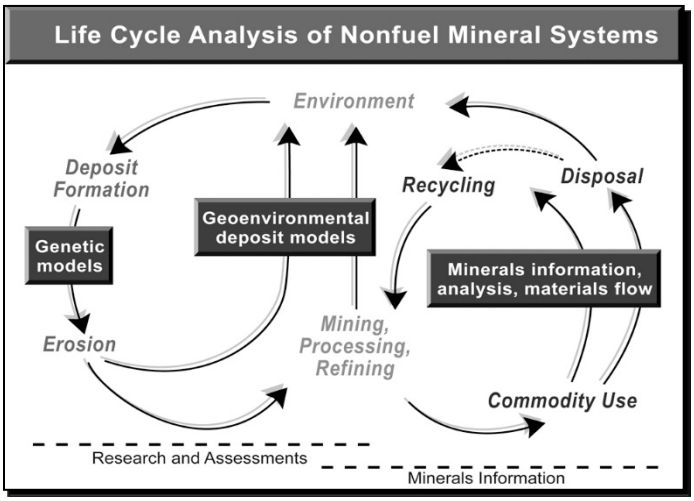
Activity: Energy, Minerals, and Environmental Health
Subactivity: Mineral Resources

2014 Actual: $45.9 million (291 FTE)
2015 Enacted: $45.9 million (291 FTE)
2016 Request: $47.7 million (305 FTE)

Overview



The Mineral Resources Program (MRP) supports data collection and research on a wide variety of nonfuel mineral resources that are important to the Nation's economic and national security. The MRP's Research and Assessment function helps to understand the geologic processes that concentrate known mineral resources at specific localities in the Earth's crust and to assess quantities, qualities, and distribution of undiscovered mineral resources for potential future supply. The program also conducts research on a wide range of critical minerals such as rare earth elements (REE), as well as the interactions of mineral resources with the environment, both natural and as a result of resource extraction, to develop geochemical baselines and better predict the impact that resource development may have on human and ecosystem health. The MRP's Minerals Information function supports collection, analysis, and dissemination of data that document production and consumption for about 100 mineral commodities, both domestically and internationally for 180 countries. This full spectrum of mineral resource science allows for a comprehensive understanding of the complete life cycle of nonfuel mineral resources and materials—resource formation, discovery, production, consumption, use, recycling, and reuse—and allows for an understanding of environmental issues of concern throughout the life cycle. Modernization of the Minerals Information function, started in 2014, includes increased emphasis on materials flow and supply chain analysis.

Program Performance

The MRP is focusing program efforts to advance the goals identified in the Energy and Minerals Science Strategy and other national and Administration priorities. In particular, in 2015, MRP increased research efforts directed toward critical minerals, minerals and the environment, and mineral information. Changes in programmatic and science center leadership have refocused and revitalized MRP's vision. The goals in this plan translate into prioritization of projects that address the following areas:

- Assessment of rare earth elements and other critical minerals.
- Refocused environmental research on development of new science and tools to reduce the impacts of minerals extraction, production, and recycling on the global environment and human health.
- Advancement of the minerals information activity, which includes increased emphasis on material flow and criticality assessment.

Efforts like these to advance the Science Strategy goals and national and Administration priorities are highlighted in the program performance section below.

Research and Assessment

(2014 Actual, $30.5 million; 2015 Enacted, $30.5 million; 2016 Request, $31.8 million)

Assessments of Rare Earth and Other Critical Minerals and Undiscovered Resources

Characterization and Identification of Critical Mineral Resources – Global demand for critical mineral commodities is on the rise with increasing applications in consumer products, computers, automobiles, aircraft, and other advanced technology products. Much of this demand growth is driven by new technologies that increase energy efficiency and decrease reliance on fossil fuels. The MRP is expanding research and assessment activities begun in 2015 to address the need for more up-to-date information on the Nation's and the world's critical mineral resources. In 2015 and 2016, the MRP would conduct geologic, geochemical, geophysical, and remote sensing surveys to comprehensively characterize the unconventional REE potential of the Appalachian front and coastal plain regions of the Southeastern United States. These include resources concentrated from the weathering of older rare-earth-bearing rocks, rare-earth-bearing placer deposits on the coastal plain associated with heavy-mineral titanium resources, and rare-earth-bearing phosphate deposits. The MRP has established working agreements with partners to better characterize significant domestic REE resources, at Mountain Pass, CA, Bear Lodge, WY, Bokan Mountain, AK, and Elk Creek, NE. This collaboration includes geophysical data acquisition and processing that will provide a better understanding of the extent of REE resources in the subsurface and help delineate geologic controls on resource distribution. The information and lessons learned from these studies will be applied in future assessments of undiscovered REE resources. Another major focus is on critical minerals in southeast Missouri, including acquisition and analysis of new geophysical data to image the subsurface. Other projects focus on less conventional critical metals in black shales, placer deposits, and certain types of gold deposits. New analytical, remote sensing, and geophysical techniques also are being developed that can aid in the understanding and characterization of critical minerals in a wide variety of geologic settings.

Geologic and Mineral Resource Studies in Alaska – The MRP is expanding its activities in Alaska to provide an up-to-date geologic foundation for mineral resource assessment activities. This work includes acquisition of new airborne hyperspectral data in central and eastern Alaska. In addition, the MRP and the State of Alaska are continuing a three-year joint effort, known as the Alaska Critical Minerals Cooperative, part of expanded research nationwide on critical minerals to evaluate critical and strategic mineral commodities such as rare earth and platinum group elements that are vital to defense, renewable-energy, and electronics technology development. This work is in conjunction with the Bureau of Land

Management (BLM) to provide the information needed to better manage Federal lands in Alaska. The MRP has analyzed information from its extensive statewide databases, and used its expertise in regional and economic geology to outline areas of Alaska with the highest potential for critical minerals. Follow-up investigations of specific geologic belts and regions will be carried out by both agencies. A specific area of focus has been the Bokan Mountain REE deposit. Another area of investigation is geophysical and geological understanding of the Yukon-Tanana region along the border between Alaska and Canada.

Mineral Commodity Criticality Assessment and Early Warning -- Under the auspices of the Critical and Strategic Mineral Supply Chains Subcommittee of the National Science and Technology Council (NSTC) of the Office of Science and Technology Policy (OSTP), a criticality assessment and early warning project has been initiated. The USGS National Minerals Information Center has agreed to take the lead role in the further development and implementation of this initiative with support from the Department of Energy, Department of Defense, Department of Commerce and other stakeholders. A commodity screening tool based on methodology developed by a subcommittee work group will be further refined and implemented to screen, on an annual basis, the portfolio of mineral commodities tracked by the NMIC. Commodities that are identified as sources of concern will be prioritized for further detailed analysis; analysis of 3-4 commodities annually is planned. By looking at changes in supply risk and the impact of supply disruption over time, it is the aim of this initiative to establish a capability to anticipate potential issues before they become a crisis. As the primary government agency responsible for the collection of mineral commodity data on the front end of the global supply chain, the NMIC is uniquely qualified to lead this effort.

Global Assessment of Undiscovered Copper, Platinum Group Metals and Potash – With the recent completion of a 10-year cooperative project providing the first-ever global assessment of undiscovered resources of copper and platinum group metals and potash—commodities essential to infrastructure, food security, and environmental health—the MRP continues to roll out the products of this large project. Never before have scientists and decisionmakers had access to a publicly available, globally consistent assessment of this type. This USGS-led international cooperative effort was conducted on a regional, multi-national basis with the participation of dozens of interested national and internal geologic, mineral resource, and other governmental and nongovernmental institutions. The final products of this international collaboration include maps and descriptions of the distribution of areas permissive for undiscovered deposits of copper and potash for specific regions of the world and the estimated quantity of metals contained in each permissive area. This body of work will form the basis for decisions about land use and mineral supply in the United States and around the world. Fifteen of the individual assessment studies have already been published and cooperative projects with other stakeholders such as the World Bank and the Department of State are being explored. A continuing project involves understanding the mineral resource potential of Afghanistan and Central Asia to assist with economic development and stabilization for both regions, emphasizing the important role that the USGS and the MRP play in the area of science diplomacy.

A**ssessment of Undiscovered Resources –** The results of topical and geographic-based research conducted by the MRP is applied to evaluate the potential of undiscovered mineral resourses and to decrease the uncertainty in probabilistic assessments. These assessments are used to inform decisions regarding potential domestic and global resource supply and decisions regarding land management of

future resource development. New work would include an assessment of platinum group elements in the Lake Superior region of the Mid Continent Rift and integrating environmental impacts into resource assessments. The MRP is continuing a collaborative effort with the Energy Resources Program (ERP) to prepare for and initiate a national uranium assessment. This project, "Uranium Resources and the Environment," draws on ERP- and MRP-funded expertise to update uranium deposit models with environmental components, develop and vet an assessment methodology, and conduct a national assessment for undiscovered uranium resources. The MRP is continuing with research and development on assessment methodology and protocol to ensure of the efficient use of all available knowledge and data in the assessment process.

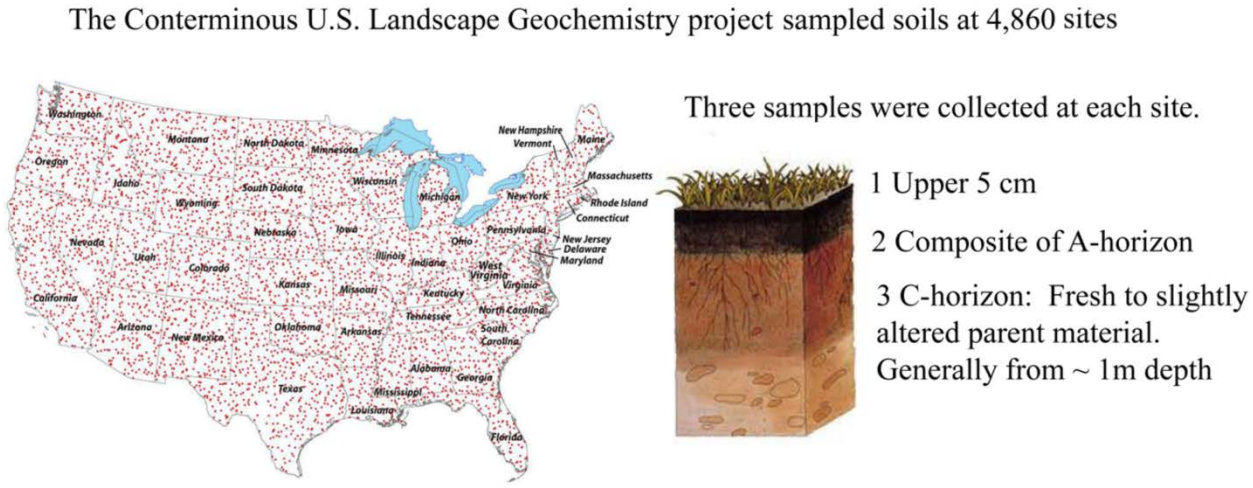
Mineral Resource Research and Information – The MRP continues to collect and analyze mineral resource data and conduct research on the genesis of and regional geologic controls for a wide variety of types of mineral resources. This includes a nationwide compilation of non-metallic mineral resources used in the industrial, construction, and agricultural industries. Another project called USMIN, in conjunction with the Bureau of Land Management (BLM), is compiling information on maps of all previous mining and mineral resource occurrences in the continental United States. This information can be useful to the BLM for land management purposes, as well as for understanding environmental impacts. The MRP will support research to better understand the genesis and regional controls on significant precious metal and critical element resources in the Yellow Pine region in central Idaho. It involves working with partners and newly available geologic data, which will lead to better understanding of the regional geology, deposits, and future resources for this type of mineralization.

New Science and Tools to Assess Minerals and Reduce Impacts of Mineral Development

Minerals and the Environment – In 2016, the MRP will develop geochemical baseline parameters to better understand, predict, and develop information and tools to minimize the impact that resource development may have on human and ecosystem health. These efforts further a more holistic, "cradle-to-grave" approach to understanding the entire lifecycle of mineral development, use, disposal and recycling. Additionally, the MRP will continue and significantly expand research on the interactions of mineral resources with the environment, both natural and as a result of resource extraction. Six new mineral environmental projects are underway in 2015 and 2016; including toxicity of multiple metals associated with PGE deposits, trace metal mobility in the Yellow Pine mining district, Idaho, groundwater quality in uranium mining, geoenvironmental-health models of mineral deposits, geoenvironmental signatures of REE deposits in Alaska, and refinement of national geoenvironmental models. Other activities include efforts to better understand emerging environmental geochemical challenges for future mining and the uses, characteristics, and environmental health implications of metal and mineral commodities in the built environment.

In 2014, the first ever soil landscape geochemistry study of the conterminous United States was released. This huge undertaking built on 4,860 sampling sites across the country—the product of which was an atlas of maps showing the distribution of 45 major and trace elements and major mineralogical components (see figure below). Continued efforts in 2015 will analyze the causes and implications of these soil variations. For example, identified anomalies for elements such as arsenic, mercury, and lead will be examined to determine possible sources and geochemical vectors for mobility and ways to display

this information in publicly available platforms such as Google Earth. This can be combined with ongoing environmental work to understand the compounding effect of multiple metal contaminates in the same watershed.



Characterization of the Midcontinent Rift and Related Mineral Resources – The MRP is refocusing efforts in data acquisition and multidisciplinary research to image and characterize the midcontinent rift and related mineral resources, to document mineral resource potential, and to evaluate mineral environmental impacts of past and future mineral resource development in the region. The midcontinent rift is a 1.1 billion-year-old structural feature exposed in the Lake Superior region, but covered by younger rocks as it extends to the South through Iowa, Nebraska, Kansas, and Missouri. Rocks that formed in response to development of the rift—such as the Duluth layered igneous complex in northern Minnesota—contain significant known resources of copper, nickel, and platinum group metals. Collaboration with partners includes sharing geophysical data and information about new resource discoveries to better understand this world-class geologic region. Other midcontinent rift studies in progress include environmental geochemistry research to evaluate impacts of past and future mining in the Lake Superior region, and an assessment of the platinum-group element resources in igneous intrusions of the Duluth complex and vicinity of the Lake Superior region. The environmental geochemistry work will explore new ways of measuring the impact of past, present, and future mineral extraction, as well as ways to mitigate those impacts.

Laboratory and Analytical Research and Development Support – The MRP supports research on analytical techniques and methods development to help characterize mineral resource genesis and mineral environmental interactions, and to provide analytical support to understand the nature and distribution of mineral resources. These capabilities also provide critical support to science and research in many other parts of the USGS. Analytical chemistry, isotope, and geochronology labs supported by the MRP provide high-caliber data to projects and programs in all USGS Mission Areas. Geophysical capabilities developed by MRP-funded scientists to discover more about mineral resource potential are now being

applied to study a variety of USGS earthquake and volcanic hazard issues, as well as groundwater aquifer characterization, and the extent of permafrost.

Minerals Information

(2014 Actual, $15.4 million; 2015 Enacted, $15.4 million; 2016 Request, $15.9 million)

The MRP, through the USGS National Minerals Information Center (NMIC), collects, analyzes, and disseminates information on the domestic and international supply of and demand for minerals and mineral materials essential to the U.S. economy and national security. The Program's goal is to provide decision makers with the information required to ensure that the Nation has an adequate and dependable supply of minerals and materials to meet its defense and economic needs at acceptable costs related to environment, energy, and economics. The public and private sectors rely on USGS minerals information to better understand the use and ultimate disposition of materials in the economy; to use national resources efficiently; and to forecast future supply and demand for minerals. Domestic and international minerals information is used in the analysis of policies, in formulating plans to deal with shortages and interruptions in supplies of minerals, and in the development of strategies to maintain a competitive position in the global economy. The NMIC's minerals and materials analysis specialists are experts on mineral industries and markets. Every month, the specialists answer more than 2,000 inquiries from, and interact with, Federal and State agencies, domestic and international organizations, foreign governments, and the general public. Also, more than 90,000 Internet and numerous facsimile queries are answered each month. Program scientists also conduct analyses of and develop information on minerals-related issues, including minerals conservation, sustainability, materials flow, availability, and the economic health of the U.S. minerals industry.

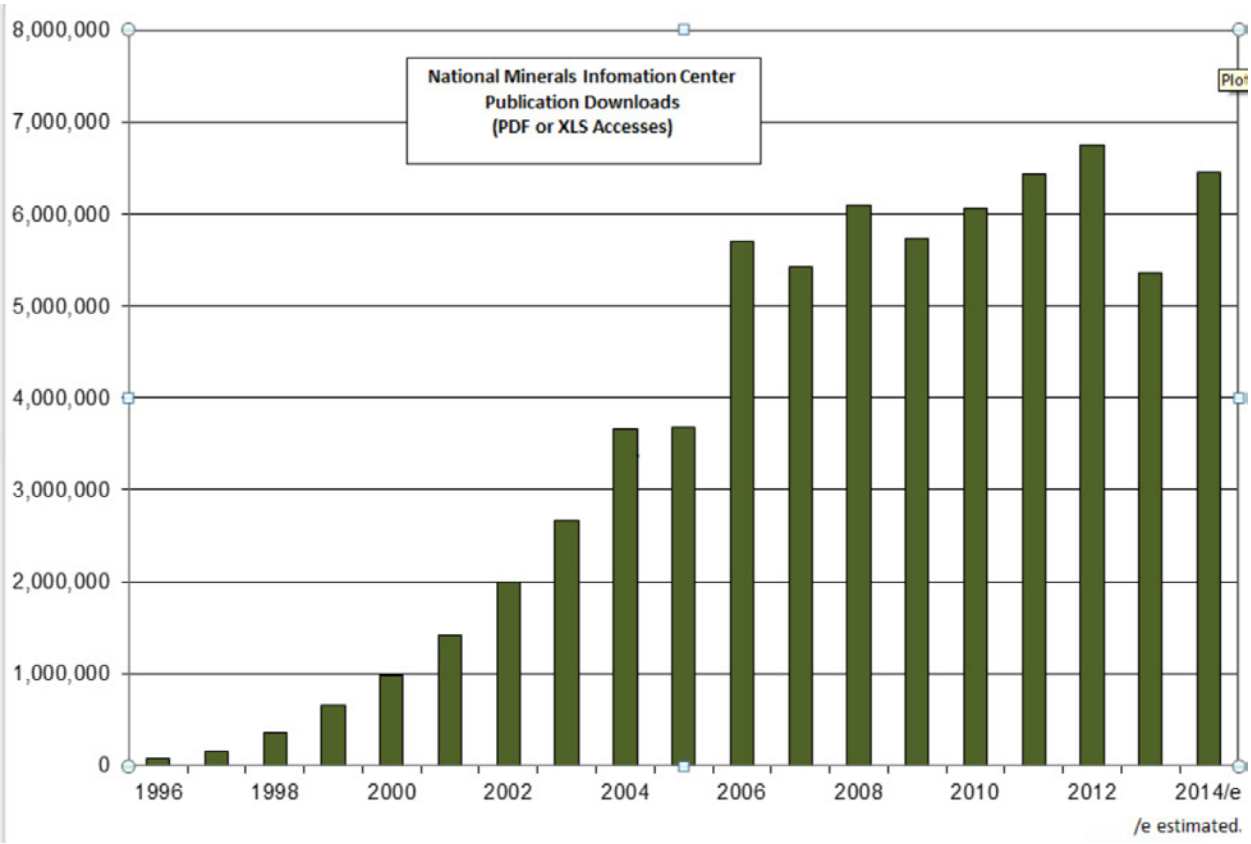
Every year, more than 700 reports are prepared by the USGS and added to the minerals information Web pages (*http://minerals.usgs.gov/minerals*). Information is organized and published by commodity, country, and State and includes:

- Mineral Commodity Summaries (annual, by commodity). This annual publication includes statistics on about 90 mineral commodities essential to the U.S. economy and national security, and addresses events, trends, and issues in the domestic and international minerals industries.
- Minerals Yearbook (annual):
    - Volume I: Metals and Minerals (by commodity);
    - Volume II: Area Reports—Domestic (by State);
    - Volume III: Area Reports—International (by country).
- Mineral Industry Surveys (monthly, quarterly, semiannually, and annually, by commodity).
- Metal Industry Indicators (monthly, for primary metals, steel, copper, primary aluminum, and aluminum mill products).
- Nonmetallic Mineral Products Industry Indexes (monthly, leading and coincident indexes for the Nonmetallic Mineral Products Industry).

Another major emphasis of the MRP and NMIC is on analyzing flows of materials. This allows other agencies, governments, and stakeholders to better understand the changes and importance of mineral resource production, consumption, and use. Recent publications include:

- *Conflict Minerals from the Democratic Republic of the Congo*
- *The U.S. Lead Recycling Industry*
- *Changing Patterns in the Use, Recycling, and Material Substitution of Mercury*
- *Barite – Import Reliance on an Essential Material for Oil and Gas Exploration*
- *Estimates of Frac-Sand Production, Consumption, and Reserves in the United States*

In 2014, the use of the USGS minerals information continued to increase. Downloads from the MRP Web site continue at a high level (see graph below), with a signature product being the annual *Mineral Commodities Summary*.



In 2015, and on a continuing basis, MRP mineral economists and minerals information specialists provide minerals information to other Federal agencies, including: the U.S. Census Bureau, the Department of Defense, the Federal Reserve Board, and the Office of the U.S. Trade Representative. MRP specialists also chair and contribute to several Office of Science and Technology Policy (OSTP)-convened working groups that will inform Federal critical minerals policy related to supply chain sustainability, research and development, and mineral information collection, analysis, and dissemination. Through workforce

efficiencies gained in 2015, the MRP will hire additional materials flow analysts to support critical mineral analyses.

The global distribution, availability, and security of supply for mineral commodities are essential for the U.S. economic and national security. The ability of the USGS National Minerals Information Center to provide fact-based information to address these issues is unmatched.

Events over the past few years have put these issues at the forefront of public policy and debate. Examples include the crisis over rare earth element supply from China, the requirements for mineral supply chain due diligence mandated by the Dodd-Frank provisions regarding conflict minerals, and economic sanctions on Russia. The National Minerals Information Center is an unrivaled resource in this arena and could be leveraged to support the broader mission of the USGS, the Department of the Interior, and the U.S. Government.

Modernization of the Minerals Information Capabilities

As part of an ongoing effort to modernize the data collection abilities of the National Minerals Information Center, a major update to the automated data information system (AMIS) began in 2014. This involves conversion from M204 to SQL programming languages and integration of AMIS and the Minerals Information Forms System into the new Minerals Information Data System. The effort is on track to be completed in 2016, and it is expected to result in program savings of $500,000 per year and increased efficiency of data collection. In addition, increased funding for materials flow and supply chain analysis will expand program capabilities to deliver needed information and analysis for this critical national area of interest. For more information, please go to: *http://minerals.usgs.gov/.*

Activity: Energy, Minerals, and Environmental Health
Subactivity: Energy Resources

2014 Actual: $26.0 million (140 FTE)
2015 Enacted: $24.9 million (140 FTE)
2016 Request: $28.1 million (149 FTE)

Overview

The USGS is the sole provider of unbiased, publicly available estimates of geological energy resources for the United States, exclusive of the U.S. Outer Continental Shelf, and provides publicly available estimates related to global oil and gas resources. The USGS also performs research to advance the science of energy resources and assessments, and to understand key impacts and issues. Major consumers of the Energy Resources Program (ERP) products are the Department of the Interior's (Interior) land and resource management bureaus, other land management and environmental agencies, national security agencies, policymakers and Congressional offices, State geological surveys and other State agencies, tribes, energy industry, environmental groups, international energy community, nongovernmental organizations, academia, and the public. The ERP provides science and information used to make decisions supporting energy security, energy policy, and environmentally sound production and utilization. The ERP-funded activities are reviewed for alignment, accountability and productivity with respect to priorities identified in the USGS Energy and Minerals Science Strategy, Secretarial priorities, Administration initiatives, congressional mandates, and customer needs. ERP activities contribute to the DOI strategic plan goal to provide science for sustainable resource use, resource protection, and adaptive management.

Program Performance

Energy Policy Act of 2005 Implementation – USGS science is a critical component to implementation of the Energy Policy Act of 2005. The Act addresses a range of energy sources, including geothermal resources, alternative energy sources such as gas hydrates and oil shale, and research on unconventional gas resources. The Act also reauthorized the Energy Policy and Conservation Act Amendments of 2000 (EPCA), in which the USGS was directed to assess oil and gas resources underlying Federal lands in the United States.

Energy Independence and Security Act of 2007 Implementation – The Energy Independence and Security Act (EISA) of 2007 called for the USGS to develop a methodology for a national geologic carbon sequestration assessment and to conduct a national assessment using the new methodology. Activities related to geologic carbon sequestration are implemented in the ERP; however, funding resides in the Climate and Land Use Change (CLU) Mission Area and a description of those activities can be found in the CLU section. EISA also called for the USGS to assist the BLM in evaluating geologic carbon sequestration on public lands. In addition, EISA directed the USGS to complete a comprehensive

nationwide geothermal resource assessment that examines the full range of geothermal resources of the United States.

Helium Stewardship Act of 2013 Implementation – The Helium Stewardship Act of 2013 (P.L.113-40) requires the USGS to, in coordination with the BLM and appropriate State geological surveys, complete a national helium gas assessment that identifies and quantifies helium resources, including the isotope helium-3, in each reservoir, including assessments of the constituent gases found in each helium resource, such as carbon dioxide, nitrogen, and natural gas. This ongoing activity is supported through the ERP-funded State Cooperatives Project, and leverages expertise from the CLU geologic carbon sequestration activity described above.

In addition to these congressional mandates, ERP-funded research aligns with a number of OMB-OSTP priorities, including (1) Clean Energy – gas hydrates, geologic carbon sequestration, geothermal energy, unconventional gas, uranium, and wind energy impact assessment; (2) Global Climate Change – geologic carbon sequestration; and (3) R&D for Informed Policymaking and Management – including Alaska petroleum studies that impact Extended Continental Shelf and U.S. Convention on Law of the Sea efforts, economic dimensions of energy resources, and produced waters/water budget assessment methods.

The ERP invests in science that supports the Administration's Grand Challenges, including "Catalyzing Breakthroughs for National Priorities – Unleashing a Clean Energy Revolution." The ERP supports research in unconventional (shale) gas resources, geologic carbon sequestration, enhanced geothermal systems, wind energy impacts, and uranium resource and impacts assessment. Further, all research funded by the ERP supports the Department's Powering Our Future and the Administration's "all-of-the-above" approach to responsible energy development.

The ERP portfolio consists of six components: National and Global Oil and Gas Resources, Geothermal Resources, Powering Our Future – Wind, National Coal Resources, Energy Information and the Environment, and the Science and Decisions Center. Brief summaries of these components are given below.

National and Global Oil and Gas Resources

(Estimates for 2014 Actual, $14.1 million; 2015 Enacted, 12.6; 2016 Request, $14.5 million)

Sources of fossil fuel supplies include a mix of domestic oil and gas fields, oil and gas imports, and unconventional resources such as shale gas, tight gas sands, coalbed methane and, possibly in the longer term, other potential resources such as natural gas hydrates. Location information and type of undiscovered global petroleum resource are critical to energy policy and energy security, and have important geopolitical implications.

Oil and gas priorities have evolved in the United States over the past decade-plus. In 2000, the focus was on coal-bed gas resources and the volumes of oil and gas resources potentially underlying Federal lands. By 2005, the massive application of horizontal drilling and hydraulic fracturing in tens of thousands of wells shifted attention to shale gas. Some fundamental issues that have arisen in recent national energy policy discussions revolve around whether the United States has the potential resource base to support

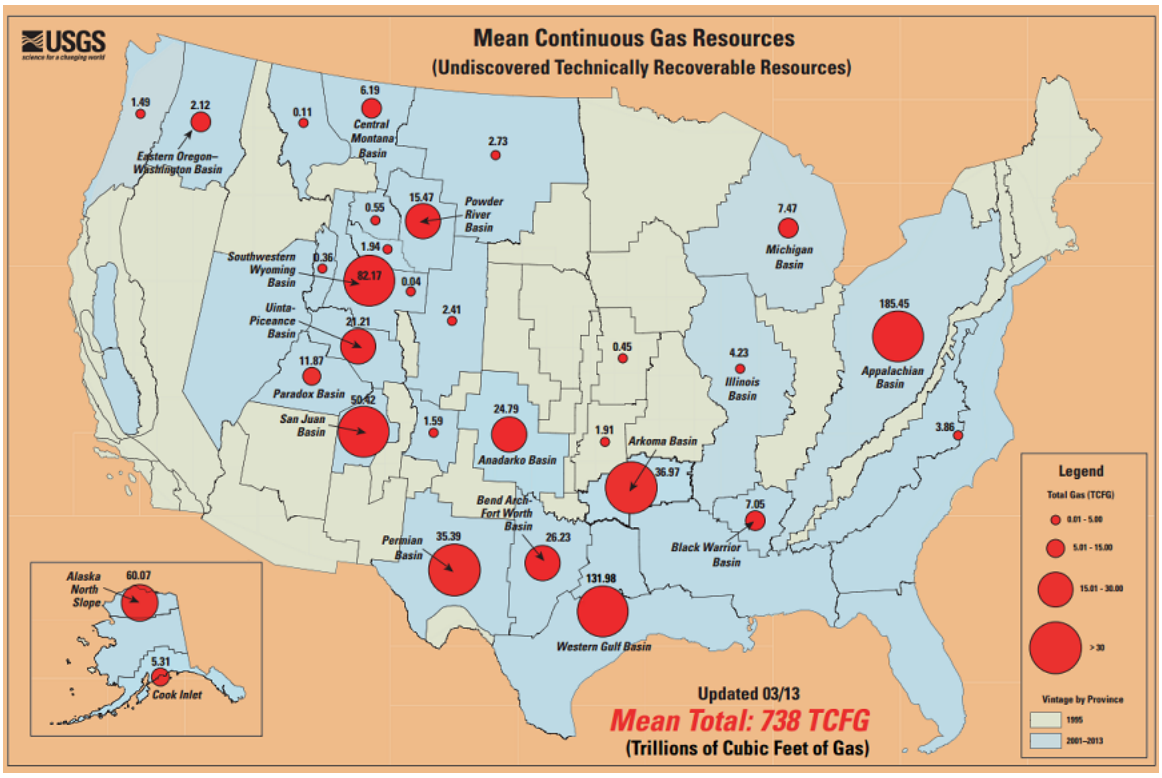
long-term gas exports, or independence from oil imports. The USGS assessments of oil and gas resources provide both insight and a baseline to begin to answer these questions.

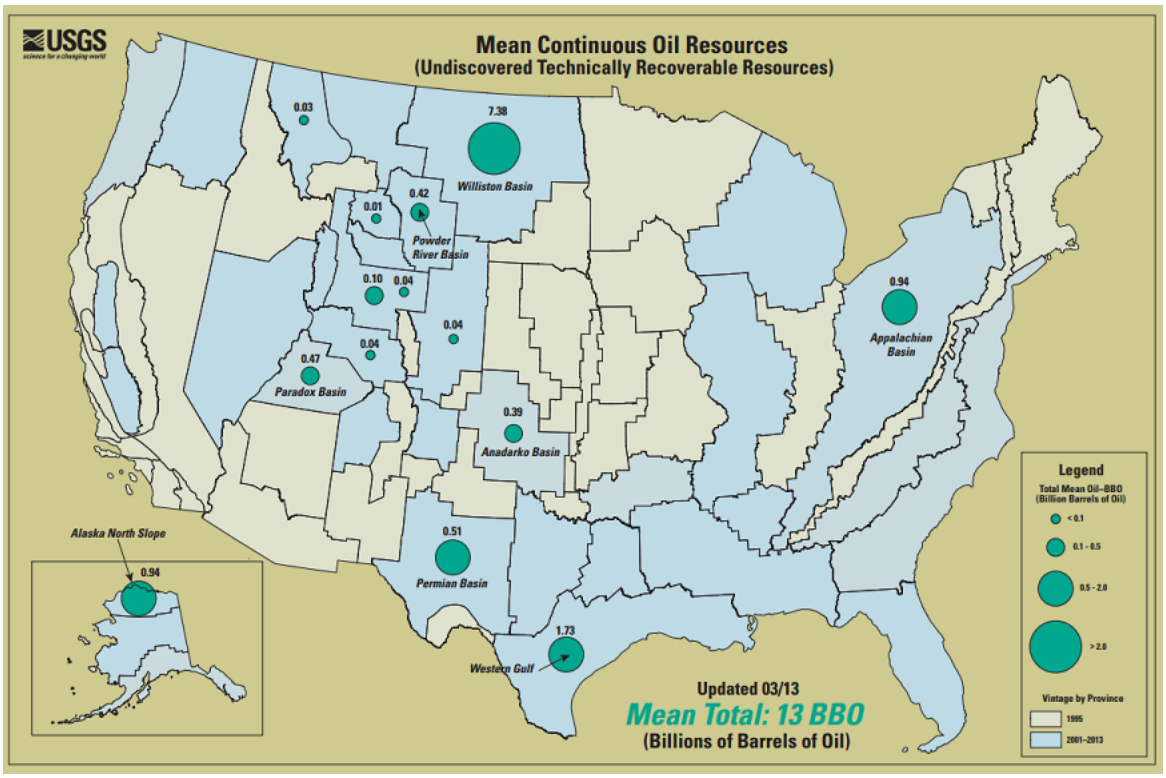
The USGS is participating in the interagency coordination activities among Interior (USGS), DOE, and EPA, in support of the April 13, 2012, Executive Order and subsequent 2014 report, *Federal Multiagency Collaboration on Unconventional Oil and Gas Research: A Strategy for Research and Development* ("*Strategy*"), aimed at providing research and technologies that support sound policy decisions by Federal, State, and local agencies responsible for ensuring the prudent development of oil and gas resources while protecting human health and the environment. The report is available at: *http://unconventional.energy.gov/*. Particular emphasis, for both domestic and global oil and gas resources, will be placed on understanding undiscovered, continuous (unconventional), technically recoverable accumulations, such as tight gas, tight oil, shale gas, and coalbed gas. Because there is currently no global unconventional resource assessment, the ERP has made this a priority, as it directly relates to the *Strategy*. Assessments will be published as they are finalized to be timely in the release of this information. In 2014, the ERP released assessments of conventional and unconventional resources of portions of Armenia, Jordan, and northeast Mexico. Work will continue in 2015 and 2016 on other areas of the world, including portions of Chile, the Baltics, Australia, China, Indonesia, and Ukraine.

In addition, the ERP is updating estimates of the volume of undiscovered oil and gas resources in the United States, including those under Federal lands, in support of the scientific inventory of oil and gas resources mandated by the EPCA. The USGS will continue to update its oil and gas resource assessments for the United States and the world using a consistent, peer-reviewed methodology as authorized in the Energy Policy Act of 2005.

In 2015 and 2016, the USGS will continue work on assessments of the Barnett Shale, the Monterey Formation in the San Joaquin and Los Angeles basins, the Mancos Shale, and the Cline Shale. In 2016, the USGS would start a new effort to compare the characteristics of unconventional gas in the Marcellus Shale both in Pennsylvania (where hydraulic fracturing is permitted) and in New York (where hydraulic fracturing is prohibited). There are areas of the Marcellus Shale natural gas trend in Pennsylvania and New York that are similar geologically, but are quite distinct regarding Marcellus gas production. For this new study, the USGS would evaluate the geologic causes of variability in the Marcellus Shale in Pennsylvania as a predictor for potential Marcellus Shale production behavior in New York.

Reserve growth is the increase in estimated volumes of oil and natural gas that can be recovered from discovered (known) fields and reservoirs through time because of delineation of new reservoirs, field extensions, or improved recovery techniques. Reserve growth in existing oil and gas fields is a phenomenon important to understanding overall petroleum supplies. Thus, the ERP has a research activity focused on this aspect of the resource spectrum. In 2015 and 2016, work on reserve growth will continue focusing on publishing additional scientific and information products.





"Bubble" maps showing mean undiscovered technically recoverable continuous (unconventional) oil and gas resources throughout the United States.

The ERP also supports studies related to the economic dimensions of energy resources, such as developing and enhancing valuation methods for economically marginal conventional and unconventional hydrocarbon resources and other energy-related non-traditional resources. Recent outcomes of this research effort have resulted in publications on stranded gas resources, to inform policymakers about important, but currently unutilized resources. Stranded gas resources are gas resources in discrete accumulations that are neither currently commercially producible, nor producible at full potential, for either physical or economic reasons.

The North Slope of Alaska is thought to have the greatest remaining petroleum resource potential of any U.S. onshore area. The USGS conducts in-depth studies of the geology and the oil and gas resources in this world-class petroleum province. Work in 2015 and 2016 will focus on improving the stratigraphic resolution of Jurassic–Tertiary strata of the Chukchi Shelf, which will help improve the understanding of petroleum systems of all of Arctic Alaska and may have implications for the United Nations Convention on Law of the Sea and improving our understanding of source and reservoir rocks in continuous (unconventional) petroleum systems, such as the Triassic Shublik Formation.

The Gulf Coast region is one of the major hydrocarbon-producing areas of the world. This ERP-funded effort provides geologic, geophysical, and geochemical framework studies necessary to enable USGS scientists to better understand and assess potential for undiscovered resources of oil, gas, and coal-bearing rocks of Texas, Louisiana, Mississippi, and Alabama; and extend potential onshore plays to the State offshore for use by the Bureau of Ocean Energy Management (BOEM) for OCS resource assessments. In support of a recent recommendation from the DOI Office of the Inspector General, the ERP and BOEM are exploring means to better facilitate information sharing and mutually enhance the bureaus' efforts to study the geologic framework of the region. During 2015 and 2016, project staff will continue framework studies and conduct assessments of the Cotton Valley Group, the Haynesville and Bossier Formations, and the Tuscaloosa marine shale.

Gas Hydrates – The USGS works extensively on U.S. gas hydrates, most notably on the Alaska North Slope and the Gulf of Mexico, and applies lessons learned from elsewhere to these domestic resources. In 2013, the USGS participated in a major research expedition in the northern Gulf of Mexico and obtained the best high-resolution seismic data and imagery ever obtained of sediments with high gas hydrate saturations. The recently completed expedition, planned jointly with the DOE, and the BOEM, was executed by the USGS. USGS scientists collected details about the nature of the gas hydrate reservoirs and about geologic features of the sediment between the reservoirs and the seafloor. The new data also provide information about how much gas hydrate exists in a much broader area than can be determined from using standard industry seismic data, which is typically designed to image much deeper geologic units.

The USGS ERP is also working with the BLM to conduct a geologic-based analysis of the occurrence of gas hydrates within northern Alaska. This analysis is part of a larger Gas Hydrate Development Lifecycle Assessment Project (a cradle-to-grave "assessment" of several representative gas hydrate "fields" in northern Alaska), designed to determine the role gas hydrates may play as a future domestic energy resource and to characterize the potential environmental and economic impact of gas hydrate exploration and development. There is substantial international interest in gas hydrates, and the USGS works closely

with the governments of several countries, including the Indian Directorate General of Hydrocarbons (DGH) and the Government of the Republic of Korea, to study, characterize, and explore for hydrates off the coasts of India and the Republic of Korea. These collaborative efforts will continue in 2015 and 2016, to help move forward the collective knowledge of this underexplored resource, and are directly applicable to studies in the United States.

Petroleum Processes – A thorough understanding of the processes that control petroleum (gas, condensate, oil, and tar) generation, migration, entrapment, and preservation in the Earth's crust is critical to making accurate scientifically sound assessments of the type, quantity, quality, and location of undiscovered petroleum resources on a national and global basis. This understanding of processes has become more important with the rising costs of petroleum fuels resulting from deeper drilling, testing of oil-shale retorting, and horizontal drilling and hydraulic fracturing often required for production of unconventional petroleum resources (i.e., tight gas sands, shale gas, shale oil, and oil shale). The ERP supports studies that apply cutting-edge research to critical issues concerning the recognition and assessment of undiscovered petroleum resources, with an emphasis on unconventional resources. As an example, the Energy Policy Act of 2005 recognized the need for updated information on domestic oil shale resources, and, in accordance with the legislation, the USGS completed assessments of Green River Formation oil shales (this is a distinctly different resource type compared to shale oil produced from wells following hydraulic fracturing). Subsequent work in 2015 and 2016 will focus on: (1) advancing techniques for study and characterization of oil shales to inform what might be technically recoverable using various production technology scenarios, and (2) contributing to a better understanding of the origin and geologic controls responsible for unconventional petroleum resources (i.e., tight gas sands, shale gas, and shale oil).

Geothermal Resources

(Estimates for 2014 Actual, $1.5 million; 2015 Enacted, $ 1.9 million; 2016 Request, $3.0 million)

In support of the Energy Policy Act of 2005, the USGS published a national assessment of conventional geothermal resources capable of producing electric power. There are also unconventional geothermal resources with potential for electrical generation. The 2007 EISA directed the USGS to complete a comprehensive nationwide geothermal resource assessment that examines the full range of geothermal resources of the United States.

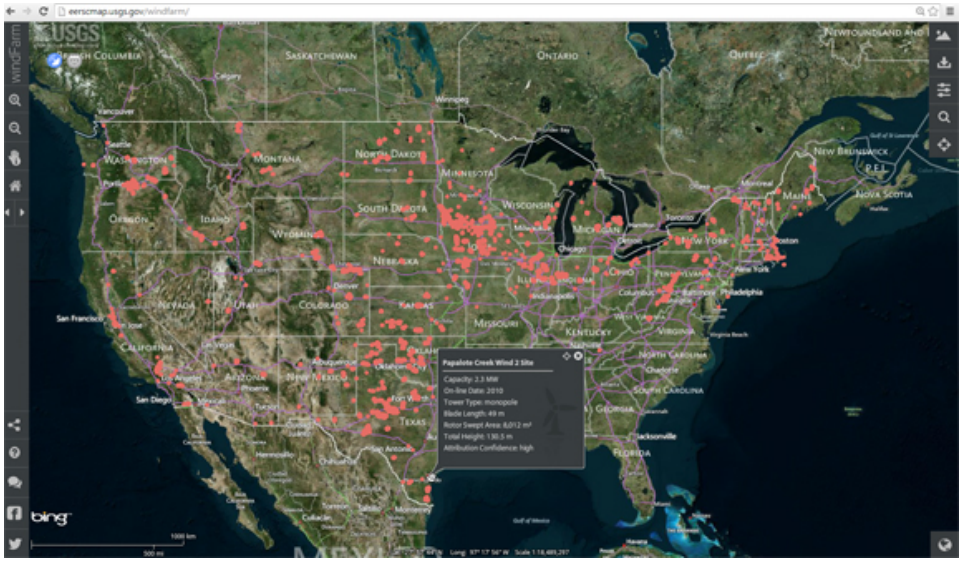
The most promising of these unconventional resources are Enhanced Geothermal Systems (EGS). EGSs are geothermal resources that require some form of additional engineering to develop permeability necessary for circulation of hot water or steam and recovery of heat for electrical power generation. New research studies, in coordination with the DOE and BLM, will focus on understanding geologic and hydrologic aspects of EGS development and providing a framework for future assessments of EGS resource potential. In 2015 and 2016, research will include studies of geothermal potential in sedimentary basins, and on developing an improved understanding of formation and evolution of permeable faults and fractures that form most geothermal reservoirs, and how they may affect resource use and relate to induced seismicity. Using this information in future assessments will better quantify the potential contribution from this domestic, renewable energy source.

In 2015 and 2016, an increased emphasis will be placed on geothermal resources on Federal lands, which have a substantial unconventional resource potential. The ERP will use core capabilities in geothermal research to evaluate the geology and subsurface characteristics, and build on a very successful recent field test, to identify likely areas of potential geothermal resource exploration and development. Proposed funding increases would allow for a focused effort to survey and subsequently track the impacts of geothermal development over time that, to date, have been poorly characterized. The increase would also allow for additional support for researching induced seismicity related to geothermal development on Federal lands, and help to determine the risks and potential mitigation plans should development be proposed. The BLM and other bureaus use this information for land use planning and potentially a targeted Environmental Impact Statement for high-grade areas.

Powering Our Future – Wind

(Estimates for 2014 Actual, $0.7 million; 2015 Enacted, $ 0.7 million; 2016 Request, $0.7 million)

In response to the Secretary of the Interior's Powering Our Future Initiative, the USGS is developing a quantitative methodology applied nationwide to assess the impacts associated with commercial wind energy development on wildlife. In 2013, the ERP sponsored workshops that brought together experts from the BLM, BIA, BOEM, FWS, NOAA, academia, industry, and nongovernmental organizations to work toward common approaches in the development of a wind energy impact-assessment methodology. Results of these workshops are guiding research and the methodology development. In 2014, the ERP released the first major wind project-related product—a national turbine dataset—which is the first publicly available dataset of industrial-scale wind turbine locations and descriptions in the United States. In addition to the dataset, the ERP developed a Web-based, GIS data viewer application to explore and access all the database content. In 2015 and 2016, the assessment methodology will be drafted and submitted to external, expert, peer review.



Screen capture of wind turbine interactive map, which can be accessed at *http://eerscmap.usgs.gov/windfarm/*, showing locations and attributes of installed turbines, as compiled from several publicly available datasets and other federal, state and local sources.

National Coal Resources

(Estimates for 2014 Actual, $1.1 million; 2015 Enacted, $ 1.1 million; 2016 Request, $1.1 million)

The USGS recently revised its assessment methodology to determine the subset of U.S. coal resources that are available for mining and are technically and economically recoverable (the coal reserve base). Federal and State land managers use these results to support land use decisions; environmental regulators use the information to evaluate compliance with regulations stemming from the 1990 Amendments to the Clean Air Act; and economists use the results to forecast economic trends at regional and national scales. The ERP works closely with counterparts at other organizations (for example, the BLM and the Energy Information Administration) to ensure revised products address a variety of needs. Analysis of the coal resources in the Greater Green River Basin will continue in 2015 and 2016.

Energy Information and the Environment

(Estimates for 2014 Actual, $7.7 million; 2015 Enacted, $7.7 million; 2016 Request, $7.5 million)

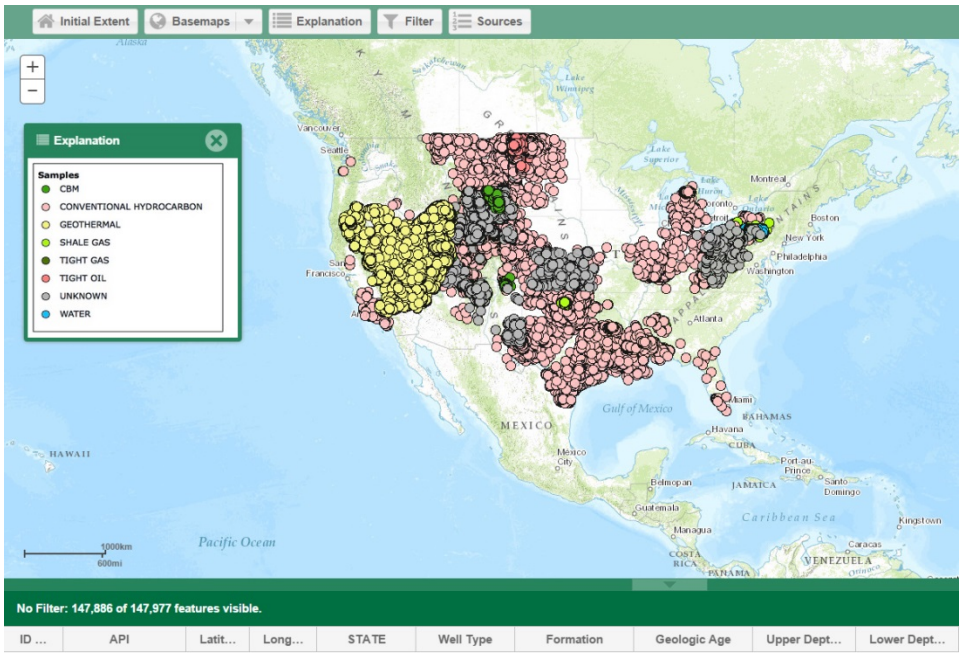
Coal Quality – Currently, coal is used as fuel for a substantial portion of domestic and international electric power generation. Although coal is a reliable, plentiful, and inexpensive energy source, coal usage carries significant environmental challenges and impacts. An understanding of coal quality is crucial to the development of methods for making coal utilization cleaner and safer through engineering advances and integration of geologic and geochemical studies on coal usage. USGS coal-quality research focuses on a range of issues that affect our Nation and the world, including land disturbances, coal emissions, coal combustion by-products, and waste handling. The USGS provides information on how sulfur, trace elements, and other substances occur naturally in coal, how these substances partition during

coal combustion, and how to quantify the fate of coal-combustion products in the environment. In 2015 and 2016, the ERP is supporting efforts to nationally characterize the coking quality of U.S. coals, and to develop holistic approaches to characterize mercury in U.S. coals.

Energy Information – Delivering information, improving the capacity to do so, and ensuring information quality and accountability are high priorities for the ERP. The ERP has worked with the DOE and OSTP to make a number of ERP products available. The ERP is working closely with the USGS Web reengineering team to build a new USGS Web site that complies with Administration and Interior requirements to improve consistency, delivery of information on mobile devices, and improve access to disabled users. The ERP is currently developing a program-wide data management plan for all of its seismic data holdings, and ERP-funded laboratory and data activities are working in concert to develop a program-wide data management plan for all laboratory data to maintain data accessibility. An ERP-wide effort to implement quality management systems is underway for all ERP-funded labs to ensure data quality and accountability. These efforts will continue in 2015 and 2016, in accordance with a recent recommendation from the DOI Office of the Inspector General.

National Coal Resources Data System (NCRDS) – The NCRDS contains information on location, quantity, attributes, stratigraphy, and chemical components of U.S. coal deposits and other stratigraphic units. A long-term partnership of the USGS and State Geological Surveys enables this sustained effort to collect and analyze basic data, build and verify the digital databases, and serve these USGS-maintained datasets. In 2015 and 2016, the State Co-op activity will continue to collect data on coal and shale gas from those States for which the USGS has current agreements, and support activities mandated in the Helium Stewardship Act of 2013.

Produced Waters – Oil and gas production often uses and yields significant quantities of water, thus information related to water and fluids associated with energy resource development is critical. ERP research will provide information on the volume, quality, impacts, and possible uses of water produced during oil, gas, and coalbed natural gas production and development. This effort will develop a methodology to estimate water budgets associated with oil and gas production and will complement oil and gas resource assessments. The ERP's base activities to understand environmental impacts associated with oil and gas development will support the aforementioned interagency coordination efforts on unconventional oil and gas development. In 2015 and 2016, the ERP will continue collaborative research on characterizing the geochemical fingerprint of produced waters, updating the produced waters database, and developing the water budget assessment methodology.



Screen capture of the Produced Waters Map Viewer, which can be accessed at *http://eerscmap.usgs.gov/pwapp/*, for the National Produced Waters Geochemical Database, showing partial listing of features and data filters available.

Uranium – Nuclear energy now accounts for about 20 percent of U.S. generated electricity. Updated knowledge of the geologic setting, occurrence, and estimates of the magnitude of the undiscovered U.S. uranium resource endowment is critical to inform planning efforts about potential domestic uranium supplies. In 2013, the ERP published a critical analysis of global uranium resources. The ERP is supporting, in conjunction with the Mineral Resources Program, development of a methodology and framework for an updated assessment of undiscovered uranium resource potential of the United States. This effort is part of an integrated study, with additional support from the Environmental Health Mission Area, to include quantitative and qualitative estimates of undiscovered uranium resources with the environmental health vulnerability related to their potential exploitation. The assessments from this integrated study are designed to be both data and knowledge-driven in their approach, using geospatial and statistical techniques, and will provide a scientific knowledge base to guide land use decisionmaking and inform national energy policy. Research in 2015 and 2016, will focus on assessing the uranium resource endowment in calcrete and phosphorite deposits, and on developing an approach that considers environmental health vulnerability associated with potential uranium mining in various geological settings.

Science and Decisions Center

(Estimates for 2014 Actual, $0.9 million; 2015 Enacted, $0.9 million; 2016 Request, $1.3 million)

The mission of the USGS Science and Decisions Center (SDC) is to advance the use of science in resource management decisions through research and applications on ecosystem services, decision science including adaptive management, and resilience and sustainability. In 2014, the SDC worked with partners to begin developing a framework for integrating energy and mineral resource assessments with

water and biological resources data to consider biophysical and economic interrelationships and the consequences of alternative decisions. A proof-of-concept effort was developed in the Powder River Basin in Wyoming. In addition, a multi-resource analysis conceptual framework was developed with potential application in a decision support tool for evaluating impacts. These efforts will advance our ability to make landscape-level decisions that consider impacts and tradeoffs from multiple natural resources and alternative decisions.

The USGS continued collaboration with Federal and non-Federal organizations to improve linkages between ecosystem services science and application through leadership in developing the scientific program for ACES (A Community on Ecosystem Services), an international conference on linking science, practice, and decisionmaking. ACES 2014, held in December 2014, brought together leaders in ecosystem services science and practice from over 30 nations to share state-of-the-art knowledge, applications, and tools for applying an ecosystem services approach to resource management decisions. The USGS worked with the USDA Natural Resources Conservation Service (NRCS) to complete an evaluation of the ecosystem services and benefits of the Sage Grouse Initiative. USGS scientists collaborated with partners in developing an economic framework for examining ecosystem services impacts on California rangelands from climate change. The SDC worked with partners to explore urban ecosystem services and how they connect with green infrastructure and published a joint report on a symposium held in Philadelphia with the University of Pennsylvania. USGS scientists also continued research on exploring applications of adaptive management and worked with partners to develop a framework for integrating adaptive management decision processes with an ecosystem services analytical framework. In addition, USGS scientists worked with partners to explore ways that an ecosystem services approach can be used to inform climate change adaptation decisions. The USGS collaborated with the U.S. Forest Service to complete a publication for middle school students on adaptive management.

In fiscal years 2015 and 2016, the SDC is working with partners to meet with diverse stakeholders on the potential structure and usefulness of a multi-resource analysis in the Powder River Basin. In addition, the USGS will extend the multi-resource analysis proof-of-concept to explore the biophysical interrelationships among geologic, hydrologic, and biological natural resources to assess the impacts of natural resource disturbances on other natural resources. The USGS will also work with partners to develop a proof-of-concept multi-resource analysis decision support tool to inform resource management decisions. The USGS continues to work with partners to explore methods for applying an ecosystem services framework to climate change adaptation decisions, and to examine metrics, valuation, and institutional/policy issues. The USGS is also examining environmental and economic supply chain issues for rare earth elements. The SDC continues to work with the USDA Office of Environmental Markets to establish a foundation for biodiversity and habitat market structures. The USGS is working with partners to examine urban ecosystem services and the use of green infrastructure, and will convene a symposium on this topic in the first half of 2015. In addition, the USGS is collaborating with partners to explore adaptive management issues, including impacts of administrative law on adaptive management.

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Activity: Energy, Minerals, and Environmental Health
Subactivity: Contaminant Biology

2014 Actual: $9.6 million (54 FTE)
2015 Enacted: $10.2 million (57 FTE)
2016 Request: $12.1 million (63 FTE)

Overview

Contaminant Biology Program (CBP) science is a key resource for managing and protecting the health of the Nation's environment, including the health of fish and wildlife populations. The Program also works in close collaboration with the public health and agricultural communities to provide the science needed to understand how environmental conditions and the health of natural resources affect people and domesticated animals. In its 2007 science strategy, the USGS identified *The Role of the Environment and Wildlife in Human Health* as a strategic focus through which the USGS "can make substantial contributions to the well-being of the Nation and the world."

The CBP, working in close collaboration with the Toxic Substances Hydrology Program (TSHP), will continue to implement the USGS Environmental Health Strategic Science Plan (EH SSP). The Program will fund research and activities that support the priorities identified in the EH SSP. To maximize resources, the CBP will continue working in close partnership with other USGS mission areas and a multitude of State and Federal agencies and non-government organizations (NGOs). These collaborative activities provide a valuable foundation for USGS leadership in the field of environmental health science. In 2016, the CBP will emphasize providing the natural science needed by resource managers, health professionals, policymakers and the public in three main areas:

- Anticipating, detecting, and preventing adverse health impacts from newly emerging environmental diseases.
- Reducing the impact of environmental diseases on the environment, fish, wildlife, and people, including improving management approaches for mitigating the health effects of combined exposure to contaminants and pathogens.
- Coordinating and supporting the portfolio of USGS activities to help the Nation prepare for and respond to health-related threats resulting from natural and manmade disasters.

Through these activities, the CBP provides leadership and science to inform regulatory decisions, enhance remediation and restoration technologies, and improve best management practices to prevent or mitigate the adverse health impacts of environmental diseases and disasters.

Program Performance

Providing the Natural Science Needed to Anticipate, Detect, and Prevent the Health Impacts of Emerging Environmental Diseases, and to Reduce the Impact of Existing Environmental Diseases

Environmentally-driven diseases are caused by disease agents such as contaminants and toxins (e.g., endocrine disruptors, pesticides, pharmaceuticals, mercury) and infectious pathogens (e.g., prions, viruses, bacteria, parasites) that constitute a critical threat to environmental health, including fish, wildlife, and people. Threats from newly emerging disease agents will continue to increase, resulting in increased health risks and economic vulnerability. Historically, scientists relied on established monitoring programs to assess changes in the environmental conditions that affect disease. That approach allows decisionmakers to react to past changes, but leaves a significant scientific gap in the Nation's ability to identify and anticipate emerging health threats. As the number of environmental health threats continues to grow and become increasingly complex, sound science, informed decisionmaking and early action will be critical for timely and cost-effective prevention and mitigation. Utilizing the strategic actions described in the EH SSP, along with input from natural resource, agricultural and public health managers, in 2016, the CBP would continue work to ensure that: (1) the Nation's capabilities for anticipating and identifying emerging environmental health threats are enhanced; (2) resources are leveraged among partners; (3) data gaps are identified and filled; and (4) information is made available to decisionmakers in a useful and timely manner.

Environmental factors influence the distribution, transmission, and severity of existing diseases. Estimates are that 24 percent of global disease and 23 percent of all human deaths are attributable to environmental factors; understanding these factors is critical. Environmental changes resulting from increasing demands for resources and changes from natural processes can increase the risk of exposure to disease agents. Exposure can occur directly from the environment (via water, soil, etc.) or from contact with other organisms (via the food chain, vector-borne, etc.). There is a significant gap in understanding how changes in environmental processes affect the health of animals and people. The CBP combines research, monitoring, and predictive models to identify and understand the sources, bioavailability, spread, and physiological impacts of emerging disease agents on fish and wildlife species.

Environmental Health and Ecological Impacts of Resource Extraction

New and continued activities in 2016 would support assessing the health and ecological impacts of resource extraction, such as hydraulic fracturing and uranium mining. These activities would be conducted in collaboration with Federal agency partners and would complement concurrent work being done by the USGS Toxic Substances Hydrology Program. In 2014, USGS published the results of research regarding endocrine active properties of hydraulic fracturing fluids and associated surface waters. In 2016, the USGS will continue to conduct research on the potential for environmental exposures to organic and inorganic contaminants in solid and liquid wastes (i.e., drill cuttings, flowback, produced water, etc.) associated with unconventional oil and gas activities. This research will allow for a more complete understanding of potential health risks to living organisms, including humans.

In 2014 and 2015, the program supported research to establish baseline concentrations of radiation and uranium exposure in sentinel species at selected new extraction sites (prior to extraction beginning). Pre-mining species inventories (currently at 200 species) and sampling of those species continued in 2014, with a primary focus on birds and bats. At the present time, these samples are being archived. In 2015, the CBP will complete the uranium baseline assessment, analyzing the pre-mining background levels of uranium in dust water, and biota, and begin modeling the 'natural' transport and occurrence of uranium and radiation in native animals and plants. In 2016, the focus of activities will shift to characterizing the mobilization of uranium during mining activities, with potential impacts on tribal resources. Samples that parallel those collected before mining would be collected during uranium extraction at active mines, and results from these samples will contribute to a modeling tool to assess ecosystem health before, during, and eventually after uranium extraction. The goal of a completed model of uranium extraction—from pre-mining to post-remediation—would be to identify management options that would best maintain environmental health and allow a healthy balance between our national mineral and biological resources. The knowledge gained from these studies will be used for developing conservation prevention and mitigation strategies to ensure that the health and sustainability of natural resources are balanced with economic development. This study will provide science needed by the Secretary of the Interior for making sound decisions regarding extraction activities on Federal lands.

Impacts of Endocrine-Disrupting Chemicals on Terrestrial and Aquatic Wildlife

In 2016, the CBP would continue to conduct studies to expand and better quantify our understanding of the endocrine disrupting properties of mercury in both terrestrial and aquatic wildlife. Historically, researchers studied the effects of pathogens and contaminants in isolation; yet animals and people are often exposed to both simultaneously. It is critical to identify and assess the potential combined effects of toxicological and infectious agents in the environment. Endocrine disrupting chemicals (EDCs) can cause reductions in reproduction, deformities, behavioral abnormalities, as well as immune dysfunction. In 2015, the CBP will continue to support ongoing high priority, EDC-related work. This work includes complementary laboratory research and field investigations focused on: (1) understanding how EDCs impact the immune function and disease resistance; (2) assessing sources and effects of agricultural-related EDCs on the health of birds, fish and amphibians; (3) identifying both trans-generational genetic effects and behavioral effects in fish and wildlife species; and (4) investigating the movement of EDCs through ecosystems to characterize risk across species and identify vulnerable species. The results of these studies will be used to better quantify risk and evaluate potential tools that resource managers might use to reduce EDC exposure and impacts in fish and wildlife species.

In 2014, the CBP conducted research focused on identifying and evaluating the long-term impacts of EDCs on fish and wildlife health in the Chesapeake Bay watershed. A team of USGS scientists assessed EDC-related research needs and science gaps from the national perspective. The national assessment enables the USGS to address the issue more strategically (on local as well as regional and national scales) and to identify opportunities where the USGS can coordinate and leverage EDC-related research and expertise. The USGS used National research priorities, in conjunction with the existing Chesapeake Bay Science Plan, to identify the highest priority science needs in the Chesapeake Bay Watershed. The science questions being addressed for the Chesapeake will provide valuable insights for important watersheds in the United States.

In 2016, the USGS would continue to fund EDC-related activities across the country with a focus on the Columbia River. The CBP will continue to investigate EDC-related effects on fish and wildlife through laboratory and field investigations in four critical areas: (1) investigations into adult on-set immune suppression following early life stage exposure of EDCs; (2) development and application of fish models to better understand EDC-induced immune suppression and disease resistance; (3) characterization of fish and wildlife models for trans-generational effects of EDCs; and (4) studies to identify reproductive effects of chronic low-dose exposure in several species including endangered sturgeon.

Impacts of Elevated Mercury Concentration on Aquatic Wildlife

The USGS is continuing to lead an international team of scientists and policy experts to conduct a synthesis of mercury cycling and bioaccumulation throughout western North America in order to quantify the influence of land use, habitat, and climate factors on mercury risk. With public land comprising more than 60 percent of the total surface area in the region, this information is critical for effective management of resources to reduce mercury effects.

Elevated mercury concentrations in aquatic habitats are a concern all over the world, and USGS scientists have been making advances in understanding this contaminant in managed wetlands and U.S. national parks. The USGS and collaborators have focused efforts on sampling forage fish from a variety of environments to enhance understanding of the patterns and processes that influence risk of mercury exposure to people and wildlife. The CBP mercury studies were leveraged, along with mercury research work being supported by the TSHP, to link mercury methylation processes with toxicological responses in sensitive wildlife.

In 2014, the USGS, in collaboration with the National Park Service, published a report on findings regarding mercury concentrations in fish from 86 remote sites across 21 national parks in the Western United States. The report describes substantial variation in fish mercury concentrations among and within parks. Mercury levels in 35 percent of fish were above a benchmark for risk to highly sensitive birds, but only 4 percent of fish exceeded the U.S. EPA criterion for protection of human health. Results indicate that mercury bioaccumulation and risk to aquatic ecosystems of western national parks is widespread, yet highly variable.

Other activities include research in the San Francisco Bay measuring mercury concentrations in fish from a range of estuarine habitats. Concentrations varied up to 15-fold among wetland sites, and were lowest in open bay and tidal wetlands and highest in managed wetland habitats. Findings highlight the importance of monitoring mercury in wetlands highly utilized by wildlife as opposed to other less utilized areas, such as large open bay habitats.

Lead Poisoning in Birds from Ammunition and Fishing Tackle

Lead is a metabolic poison that can negatively influence biological processes leading to illness and mortality in North American birds. Lead ammunition and fishing tackle are an important source of avian lead poisoning due to their widespread recreational and subsistence use in wildlife habitats. A paper authored by USGS scientists and colleagues reviews current studies that have focused on lead poisoning

in birds to address how and to what extent birds are exposed to lead in ammunition and fishing tackle, and the options for and effective ways to reduce future exposure. Authors also explore the measures that others have taken to reduce birds' exposure to lead and highlight aspects of effective lead reduction strategies.

Disaster Resilience: Helping the Nation Prepare for and Respond to Health-Related Threats Resulting from Natural and Manmade Disasters

The USGS has internationally recognized expertise related to the environmental health impacts of disaster, impacts that can affect public health, animal health, and the economic well-being of the Nation. The USGS provides science to Federal agencies tasked with responding to immediate and long-term environmental health impacts of natural and anthropogenic disasters. A disaster event can be a catalyst for the release of hazardous materials containing contaminants or pathogens into the environment (e.g., leaking of radiation after earthquake damage to a nuclear reactor, release of contaminants or pathogens from a wastewater treatment plant due to flooding), or can result in environmental conditions that can promote infectious disease outbreaks.

The CBP serves as the USGS point-of-contact for coordinating the portfolio of the USGS chemical and biological threat preparedness and response activities. The USGS partners with and provides expertise to Interior, the Department of Homeland Security (DHS), the U.S. Department of Agriculture (USDA) , the Department of Health and Human Services (HHS), the U.S. Department of State (DoS), the Department of Defense (DoD), the Smithsonian Institute, and the U.S. Agency for International Development (USAID) to develop disease models, maps, and diagnostic tools for detecting health threats related to disasters and provides advice on response strategies for fish, wildlife and zoonotic diseases. For example, *"The White House National Science and Technology Council Subcommittee on Foreign Animal Disease Threats (FADT) 2012-2016 Research and Development Plan"* identifies as a high priority development of an interagency framework for preparing for and responding to high consequence diseases (HCDs) in wildlife such as migratory birds and whitetail deer. The HCDs have the potential to produce significant public health, agricultural, ecological and economic impacts.

Due to concerns regarding terrorism, there is an increasing awareness of the value of using fish and wildlife disease events as a system for detecting human health threats due to naturally occurring or intentionally introduced chemical agents and zoonotic diseases (diseases transmissible between animals and people). Many of the "Select Agents and Toxins" listed in the National Select Agent Registry (a list of select pathogens and toxins deemed a potential threat to human or animal health) can affect or be transmitted by fish or wildlife. At the request of State and Federal partners, CBP scientists conducted field investigations of fish and wildlife mortality events and developed new methods for detecting and understanding the effects of environmental disease agents. In 2015, the USGS continued to lead and expand this effort by working closely with State and Federal agencies, non-governmental organizations and academia on high priority tasks such as the development of predictive modeling and forecasting tools for assessing the risk of emerging health threats. In 2016, USGS would continue to serve as Federal lead agency in this area.

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Activity: Energy, Minerals, and Environmental Health
Subactivity: Toxic Substances Hydrology

2014 Actual: $10.0 million (55 FTE)
2015 Enacted: $11.2 million (61 FTE)
2016 Request: $15.4 million (78 FTE)

Overview

The Toxics Substances Hydrology Program (TSHP) supports environmental contamination research, which provides reliable scientific information and tools that explain the occurrence, behavior, and effects of toxic substances in the Nation's natural environments.

Contamination problems addressed by the TSHP are widespread and pose significant risk to human health and the environment. The TSHP focuses on contamination issues of emerging concern based on input from Federal, State, tribal and local entities, nongovernmental organizations, and others. The program supports laboratory and field-based research conducted by large multidisciplinary teams of USGS and other scientists. Field studies are conducted at representative sites, watersheds, or regions. Results provide a foundation for informed decisionmaking by resource managers, regulators, industry, and the public, helping to improve environmental monitoring, characterize and manage contamination, develop best management practices, form regulatory policies and standards, register the use of new chemicals, and guide chemical manufacture and use.

The TSHP reacts rapidly to emerging issues; develops new methods and collects field data in the most susceptible environmental settings across the Nation; maintains field networks and research sites that provide a focal point for interdisciplinary research; addresses contamination problems at a wide range of geographic scales and environmental settings; and provides fundamental knowledge of the inherent clean-up capacity of our natural environments. Scientific findings are distributed broadly via briefings, workshops, technical meetings, and scientific reports. In the five-year period from 2010–2014, the TSHP produced about 775 scientific publications. The program directly supports the USGS Science Strategy and Interior goals by providing a landscape-level understanding of point and non-point sources of contamination as a foundation for decisionmaking. In 2015 and 2016, the TSHP will work closely with the CBP to implement a national research strategy for environmental endocrine disruption, and will continue to implement the USGS Environmental Health Science Strategy.

Program Performance

The TSHP has two primary components: “Contaminated Site Characterization and Remediation (point-source contamination),” and “Investigations of the Environmental Impacts of Watershed and Regional-Scale Contamination (non-point source contamination).”

Contaminated Site Characterization and Remediation

These investigations improve capabilities to describe, manage, and remediate subsurface contamination from local releases, such as chemical spills, leaking storage tanks, industrial discharges, and leakage from landfills and other waste facilities. The knowledge and new methods developed at intensely studied, representative sites are applied to similar sites across the Nation. In 2015 and 2016, the TSHP will evaluate all research activity priorities in context with implementation of the Environmental Health Strategic Science Plan. In 2015, the TSHP will continue to support long-term investigations and understandings of subsurface movement of contaminants associated with: (1) an oil spill from a ruptured pipeline (Bemidji, MN), (2) radionuclides associated with a legacy mill tailings site (Rifle, Colorado) , (3) contaminants associated with storage of low-level radioactive waste sites (Amargosa Desert, Nevada), and (4) solvent contamination at a closed Navy testing facility in a sedimentary fractured rock aquifer (New Jersey) in order to develop more accurate tools and help inform management and remediation decisions.

Remediation of Oil Spill from Pipeline Still Challenging after 30 Years – An environmental release of crude oil occurred at Bemidji, MN, in 1979. The Bemidji spill is now over 30 years old and the TSHP-supported research site there is the only long-term study site in the world available for understanding the controls on the timeframe for remediation and natural attenuation of petroleum hydrocarbons in the subsurface. In 1998, the pipeline company installed a dual-pump recovery system designed to remove crude oil remaining in the subsurface at the site. The remediation from 1999–2003 resulted in removal of about 115,000 liters of crude oil, representing between 36–41 percent of the volume of oil (280,000 to 316,000 L) estimated to be present in 1998. In 2014, the TSHP provided evidence that management of wastes associated with the dual-pump recovery system used at the spill site is linked to expansion of the anoxic zone of groundwater upgradient and beneath the existing natural attenuation plume. Consequently, this research shows that oil-phase recovery was limited and considerable volumes of mobile and entrapped oil remain in the subsurface despite remediation efforts for 30 years. In 2014, TSHP researchers published a book chapter summarizing the state-of-science on petroleum fingerprinting using organic compounds. This technique distinguishes contamination due to current petroleum spills from baseline contaminant levels before spills. These research activities will continue in 2015 and contribute to our increased knowledge about the long-term dynamic nature of petroleum spills and the efficacy of clean-up activities. In 2015, TSHP researchers will provide evidence that natural attenuation reactions in the oil plume have enhanced the mobility of toxic elements such as arsenic, thereby increasing their concentrations in the groundwater. This documents the collateral damage that can persist in the environment due to these types of spills and associated groundwater plumes.

Environmental Impacts of Watershed- and Regional-Scale Contamination

These investigations address nonpoint-source contamination problems typical of widespread land uses or human activities that may pose a threat to human and environmental health throughout a significant portion of the Nation. These investigations include developing laboratory and field methods to ensure accurate measurement of contaminants, characterizing contaminant sources, investigating mechanisms by which contamination affects aquatic ecosystems, and investigating the processes that transform contaminants into different and possibly more toxic forms. In 2015 and 2016, the TSHP will evaluate all

research activity priorities in context with implementation of the Environmental Health Strategic Science Plan. In 2015, the TSHP is increasing research emphasis on contamination potentially associated with a range of energy extraction, including conventional and unconventional oil and gas (hydraulic fracturing flowback and produced waters) and uranium. Additionally, in 2015, new method development activities will expand to include more disinfection byproducts as well as chemicals associated with unconventional oil and gas wastewaters.

Furthermore, the TSHP's 2015 activities include continued exploration of a range of emerging contaminant research topics, such as those associated with new pesticides and their formulations, pharmaceuticals, and algal toxins. For example, in 2014, the TSHP continued analysis of environmental samples previously collected from streams across the Nation to characterize complex chemical mixtures and identify new environmental contaminants using forensic approaches. The EPA is participating in this study and is using field samples and chemical analyses provided by the USGS to test new screening assays for biological activity. These collaborative efforts will continue to expand in 2015.

In collaboration with the Energy Resources, Mineral Resources, and Contaminant Biology Programs, the TSHP is also studying the environmental impacts of metals and uranium mining. In 2015, the TSHP will continue its collaboration with the Contaminant Biology Program to determine the sources of contaminants causing endocrine disruption (e.g., intersex) in fish of the Chesapeake Bay watershed. The programs will build upon collaborative endocrine disruption research in the Chesapeake Bay, as well as in several National parks, including: Rocky Mountain National Park; Congaree National Park and the Northern Colorado Plateau Network; Boulder Creek, Colorado; and others. The goal of this effort is to develop a national strategy to investigate endocrine disruption in aquatic and terrestrial organisms.

Liquid and Solid Wastes Associated with Unconventional Oil and Gas Activities As Source of Environmental Contaminants – In 2015, the TSHP will be exploring the potential for biocides, corrosion inhibitors, surfactants, and other chemicals known or suspected to be associated with wastewaters from unconventional oil and gas (UOG) activities to be released into the environment. Once in the environment, these contaminants may have environmental health impacts. For example, biocides may inhibit indigenous soil and aquifer bacteria from normal microbial functions such as the natural attenuation of contaminants. In 2014, TSHP research focused on the relations between microbial communities and the chemistry of the wastewaters as the first step in determining what impacts may occur in the environment. In addition, research assessed soils and streambed sediments for contamination at a facility where UOG wastewaters are stored and processed for deep-well injection and are suspected to have leaked into the environment. As part of that work, new analytical methods to detect a range of chemicals known, or suspected to be, associated with UOG wastewaters are being tested. Data and results from the research at this UOG wastewater processing facility will be published in 2015.

New and Understudied Pesticides Detected in the Environment – In 2014, the TSHP provided evidence of the widespread occurrence of neonicotinoid pesticides in settings across the Nation. Neonicotinoids exposures to pollinators have been linked by other researchers as a potential causal factor in Colony Collapse Disorder in honeybees. In 2015, the TSHP will be continuing to expand method development activities and field studies to include the active pesticide ingredients, as well as their degradates and the so-called inert ingredients (e.g., surfactants), commonly used in pesticide formulations

to enhance their efficacy in the field. In 2014, TSHP scientists published data showing that glyphosate (a common herbicide used to control broad-leafed weeds worldwide) as well as its degradate compound, aminomethylphosphonic acid (AMPA), co-occur frequently in environmental soils, water, and precipitation in the United States. Other scientists have associated some of these inert ingredients with adverse environmental health impacts such as pesticide enhancements when they are mixed with various other chemicals. In 2015, TSHP researchers will be testing the environment for the inert ingredient polyoxyethylene tallow amine (POEA), which is commonly used during glyphosate applications (see below). In 2014, TSHP researchers integrated assessments of the processes controlling mercury methylation in the world's major oceans.

Measuring the Inert Ingredients in Common Herbicide Formulations – Polyoxyethylene tallow amine (POEA) is added to the original formulation of the herbicide glyphosate to aid in its application and effectiveness at controlling weeds. A variety of these inert ingredients—commonly called adjuvants—such as POEA (a surfactant) are commonly mixed with active pesticide ingredients to increase their efficacy in field settings, although little is known about these ingredients and their occurrence, transport, and effects on exposed organisms. Some adjuvants such as POEA have demonstrated toxic effects on aquatic or other non-target organisms. USGS scientists have developed methods to measure POEA in the environment. These methods have shown that there exists a complex and variable mixture of POEA-related compounds in the environment, and that POEA is a common additive in several newer agricultural and household glyphosate formulations. Since glyphosate is one of the most widely used pesticides in the United States, the findings could indicate that POEA may be widely available for transport into surface water and groundwater—a question that TSHP scientists began investigating in 2014, and will continue to investigate and issue publications on in 2015.

Toxic Disinfection Byproducts Are Released into the Environment from a Variety of Wastewater Sources – In 2013, waters produced as a byproduct of oil and gas development were found to yield high concentrations of disinfection byproducts (DBPs) when treated. This was the first time that these oil and gas activities were shown to contribute DBPs to streams where the wastewaters are discharged. TSHP research on DBPs as environmental contaminants continued in 2014. In 2015, researchers will document results of analyses of new samples collected from a range of potential sources and pathways to the environment, such as municipal wastewater treatment plants, public swimming pools, drinking water, and dairy operations.

Environmental Mercury Cycling and Global Change – Recent research by USGS scientists supported by the TSHP, in collaboration with Harvard University, has shown that rising global temperatures and changing human actions will significantly affect the environmental distribution of mercury worldwide. Higher temperatures and weaker air circulation patterns from climate change will likely have significant impacts on the atmospheric lifetime and patterns of mercury deposition. In most climate change scenarios, storms will be less frequent but more intense, resulting in larger amounts of mercury being released from the soil through erosion that may end up in rivers, lakes and oceans. Mercury that reaches these surface waters can be processed by naturally occurring bacteria into methylmercury, an extremely toxic form of mercury that bioaccumulates in the food web. A majority of present mercury releases to the environment are atmospheric emissions from human activities and reemissions of previously deposited mercury from soils and the oceans. The largest sources of manmade mercury emissions are small-scale

gold mining and burning coal for electrical generation. Changes in human behavior will also have substantial impacts on global mercury. Current human emissions of mercury total 2,000 metric tons per year. Under the best-case scenario of curbing human emissions, that number could fall to 800 metric tons per year by 2050. If no actions are taken, the number will likely increase to 3,400 metric tons per year by 2050.

Potential Environmental Health Implications of Legacy and New Uranium Mining Activities – In 2014, TSHP researchers, in collaboration with other Federal partners and USGS scientists, documented the baseline concentrations of uranium and other related toxic elements in and near a permitted uranium mine that is not yet operational. The baseline data will be published in 2015 and made available to future users conducting comparative research after the mine becomes active. In 2015, TSHP researchers will begin work plans to investigate the potential environmental health implications resulting from the legacy of former uranium mining activities.

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Natural Hazards

Activity: Natural Hazards

		2014 Actual	2015 Enacted	2016 Fixed Costs and Related Changes (+/-)*	2016 Internal Transfer	2016 Program Changes	2016 Budget Request	Change from 2015 (+/-)
Earthquake Hazards ($000)		53,803	59,503	651	0	-2,202	57,952	-1,551
	FTE	232	236	0	0	-4	232	-4
Volcano Hazards ($000)		23,121	25,121	388	0	200	25,709	588
	FTE	138	140	0	0	1	141	1
Landslide Hazards ($000)		3,485	3,485	54	0	500	4,039	554
	FTE	19	19	0	0	2	21	2
Global Seismographic Network ($000)		4,853	4,853	26	0	4,920	9,799	4,946
	FTE	11	11	0	0	2	13	2
Geomagnetism ($000)		1,888	1,888	36	0	1,700	3,624	1,736
	FTE	12	12	0	0	3	15	3
Coastal & Marine Geology ($000)		41,336	40,336	611	174	4,109	45,230	4,894
	FTE	205	204	0	1	7	212	8
Total Requirements ($000)		**128,486**	**135,186**	**1,766**	**174**	**9,227**	**146,353**	**11,167**
Total FTE		**617**	**622**	**0**	**1**	**11**	**634**	**12**

**Fixed Costs are $1,438 and Seasonal Federal Health Benefits are $328*

Summary of Program Changes

Request Component	($000)	FTE	Page
Earthquake Hazards	**-2,202**	**-4**	
Natural Hazard Science for Disaster Response: EEW and Event Characterization	-1,502	-2	C-36
Precision Monitoring for Non-Seismic Fault Activity	-700	-2	C-41
Volcano Hazards	**200**	**1**	
All-of-the-Above Energy: Renewable Energy - Geothermal	200	1	C-72
Natural Hazard Science for Disaster Response: Response to Volcanic Hazards	0	0	C-35
Landslide Hazards	**500**	**2**	
Natural Hazard Science for Disaster Response: Landslide Response	500	2	C-38
Global Seismographic Network	**4,920**	**2**	
Natural Hazard Science for Disaster Response: GSN Primary Sensor Deployment	4,920	2	C-37
Geomagnetism	**1,700**	**3**	
Natural Hazard Science for Disaster Response: Improved Geomagnetic Monitoring to Support Space Weather Nowcasting	1,700	3	C-37
Coastal & Marine Geology	**4,109**	**7**	
Critical Landscapes: Arctic	2,000	4	C-21
Resilient Coastal Landscapes and Communities: Resilience & Vulnerability	2,109	3	C-31
Total Program Change	**9,227**	**11**	

Justification of Program Changes

The 2016 Budget Request for Natural Hazards is $146,353,000 and 634 FTE, a net change of +$11,167,000 and +12 FTE from the 2015 Enacted. For more information on Natural Hazards Mission Area changes, please see Section C, Program Changes as indicated in the table.

Activity Summary

The Natural Hazards Activity is comprised of six subactivities:

- Earthquake Hazards Program (EHP; *http://earthquake.usgs.gov*)
- Volcano Hazards Program (VHP; *http://volcanoes.usgs.gov*)

- Landslides Hazards Program (LHP; *http://landslides.usgs.gov*)
- Global Seismographic Network (GSN; *http://earthquake.usgs.gov/monitoring/gsn*)
- Geomagnetism Program (*http://geomag.usgs.gov*)
- Coastal and Marine Geology Program (CMGP; *http://marine.usgs.gov*)

Natural hazards threaten the safety, security, and economic well-being of our Nation's communities as well as impact natural resources and surrounding ecosystems. Much of the Nation's infrastructure is aging and vulnerable to sudden extreme events and the cost of response to and recovery from disasters continues to rise. Expanding population in coastal zones, floodplains, wildland-urban interfaces, and areas prone to earthquakes, landslides, and volcanic eruptions heightens risk of future disasters.

In the face of these challenges, the USGS provides scientific information to emergency responders, policymakers, and the public to reduce losses from earthquakes, floods, hurricanes, landslides, magnetic storms, tsunamis, volcanic eruptions, and wildfires. Working with its partners, cooperators, and customers, the USGS delivers actionable assessments of these hazards and helps to develop effective strategies for achieving more-resilient communities.

The USGS is the Federal agency responsible for monitoring and notification of earthquakes, volcanic activity, and landslides in the United States. For many other hazards, the USGS directly supports the warning responsibility of the National Oceanic and Atmospheric Administration.

This mission area includes USGS activities that characterize and assess coastal and marine processes, conditions, change and vulnerability. USGS expertise in marine geology, geophysics, and oceanographic disciplines provides science and information products essential to the implementation of priority objectives, and identifies critical needs for science and information to support broad objectives that include ecosystem restoration and protection, adaptation to climate change, and sustainable development and resources use. The USGS actively engages with other Interior bureaus, Federal agencies, and regional ocean alliances to provide data and tools to support national and regional objectives. USGS efforts to improve and increase understanding in these areas provides managers and policymakers at all levels with tools to make better and more cost effective decisions that anticipate changing conditions and the consequences of resource use, management, and restoration.

Through the Science Application for Risk Reduction (SAFRR) project, the USGS is working with emergency and business continuity managers to improve warning systems, explore vulnerable interdependencies, enhance emergency response, and speed disaster recovery. SAFRR, created in 2011, builds on the successful Multi-Hazards Demonstration Project that innovated ways of applying USGS hazard science to improve the resilience of southern California. Scenarios developed by that project led to the Great ShakeOut public preparedness drills that have grown worldwide to include over 22 million people in 2014. The ShakeOut scenario detailed earthquake vulnerabilities that the City of Los Angeles is now beginning to address. The same approach of building an end-to-end scenario of catastrophic impacts has been applied to a California-wide winter storm in the ARkStorm scenario. ARkStorm is now being used by emergency managers and others for drills to work through the cascading impacts of an event that strikes California as frequently as large San Andreas earthquakes and holds potentially greater

consequences. The SAFRR Tsunami Scenario was released in September 2013, through five workshops hosted by the State of California for coastal emergency managers, and is being used for a planned exercise in California and Washington in March 2014. The next scenario, Haywired, will look at the impact of a large Hayward fault earthquake on the digital economies of Silicon Valley. The SAFRR project will continue to build alliances and work with communities, businesses, research institutions, and governments, to improve the use of existing USGS natural hazards information, to identify needs and gaps, and to develop new products that increase the effectiveness of USGS science. Scenarios akin to ShakeOut and ARkStorm will remain a cornerstone activity. These science-based scenarios are recognized internationally as a fundamental shift in the way science can communicate to serve society.

The Department of the Interior (Interior) Strategic Sciences Group (SSG) was created by a 2012 Secretarial Order to provide the Secretary of the Interior with the standing capacity to rapidly assemble trained teams of scientists to construct interdisciplinary scenarios of the cascading consequences of natural disasters and other environmental crises. With co-leaders from the USGS and one other Interior bureau (currently the National Park Service), the SSG complements the other activities of the USGS Natural Hazards Mission Area during both crisis and non-crisis times. During an environmental crisis, the Secretary can direct the SSG to activate a crisis science team composed of experts from government, academia, non-governmental organizations, and the private sector to build scenarios, develop potential interventions to mitigate adverse effects, and deliver information to decisionmakers and resource managers. In 2013, the SSG deployed to support the Interior in its role on the Federal Hurricane Sandy Rebuilding Task Force. For this work, the SSG developed scenarios to examine the impacts on the ecology, economy, and people of the affected region. The scenarios included interventions that could improve regional resilience to future major storms. The SSG used scenario results to develop criteria for Interior's selection of projects to be supported by Hurricane Sandy supplemental funds. In 2014 and 2015, the SSG forged partnerships with multiple professional societies to expand its roster of science experts from diverse disciplines and sectors to call on during deployment. In addition, the SSG has been consulted by project teams both within and outside Interior to provide input, based on the SSG's work during Hurricane Sandy, on developing project assessment techniques and developing scenarios for rapid response. For 2015, the SSG will be preparing for Secretarial deployment in the event of a future crisis affecting Interior-managed resources. During non-crisis times, the SSG refines the scenario development methodology, makes necessary preparations for future deployments, and conducts training exercises to build a cadre of deployable experts.

As a result of the bureau's realignment of functions and responsibilities, emergency management was realigned from the Director's immediate office to the Office of the Associate Director for Natural Hazards. The Deputy Associate Director for Natural Hazards serves as the USGS Emergency Management Coordinator and works closely with the Interior Office of Emergency Management, FEMA and other agencies and organizations to execute the emergency management responsibilities of the bureau. The bureau's Hazard Response Executive Committee (HREC) also is managed from this office. The skills and expertise of many USGS employees are used to respond to a variety of natural hazards and related emergencies. The USGS takes seriously its responsibility to provide necessary resources to plan, prepare, respond, and recover from emergencies.

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Activity: Natural Hazards
Subactivity: Earthquake Hazards

2014 Actual: $53.8 million (232 FTE)
2015 Enacted: $59.5 million (236 FTE)
2016 Request: $58.0 million (232 FTE)

Overview

Of all natural hazards facing the United States, earthquakes have the greatest potential for inflicting catastrophic casualties, damage, economic loss, and disruption. Damaging earthquakes are infrequent, but their consequences can be immense. According to recent studies, a major earthquake in an urbanized region of the United States could cause several thousand deaths and approximately $250 billion in losses. In addition to California, many other parts of the country are also at risk, including the Mississippi River Valley, Pacific Northwest, Intermountain West, Alaska, Hawaii, U.S. Territories, and parts of the Eastern seaboard. Population growth over the past decade has increased exposure to earthquake risk, putting a large percentage of American households and businesses at risk for earthquake damage.

The USGS provides the scientific information and knowledge necessary to reduce deaths, injuries, and economic losses from earthquakes and earthquake-induced tsunamis, landslides and liquefaction. The USGS is the only U.S. agency that routinely and continuously reports on current domestic and worldwide earthquake activity. Through the Advanced National Seismic System (ANSS), the USGS and its State and university partners monitor and report on earthquakes nationwide.

The Earthquake Hazards Program (EHP) is the applied Earth science component of the four-Agency National Earthquake Hazards Reduction Program (NEHRP, reauthorized by the Earthquake Hazards Reduction Authorization Act of 2004, P.L. 108–360). A reauthorization bill for the program is currently under consideration in Congress. Through NEHRP, the USGS partners with the Federal Emergency Management Agency (FEMA), the National Science Foundation (NSF), and the National Institute of Standards and Technology (NIST) to reduce earthquake losses in the United States.

The EHP includes the following four program components, described in more detail below: Assessment and Characterization of Earthquake Hazards; Monitoring and Reporting Earthquake Activity and Crustal Deformation; Conducting Research into Earthquake Causes and Effects; and Earthquake and Safety Information for Loss Reduction.

Partnerships are crucial to the program's success. Approximately one-quarter of the total EHP budget is directed toward research grants and cooperative agreements with universities, State agencies, and private technical firms to support research and monitoring activities. This external funding is leveraged by funds from other Federal agencies, States, and the private sector.

Direction for the EHP is established in the strategic plans of the USGS and the Department of the Interior, through periodic reviews by the congressionally established external Scientific Earthquake Studies Advisory Committee, and through communication with partners and stakeholders. EHP-funded activities undergo both management and scientific review of project concepts and final project proposals when submitted for initial funding using a Program Council responsive to regional and topical needs.

Program Performance

Assessment and Characterization of Earthquake Hazards

The USGS contributes to earthquake hazard mitigation strategies by developing seismic hazard maps that describe the likelihood and potential effects of earthquakes nationwide, especially in the urban areas of highest risk. Federal, State, tribal, and local government agencies, architects and engineers, insurance companies and other private businesses, land use planners, emergency response officials, and the general public rely on the USGS for earthquake hazard information to refine building codes, develop land-use strategies, safeguard lifelines and critical facilities, develop emergency response plans, and take other precautionary actions to reduce losses from future earthquakes.

The USGS National Seismic Hazard Maps are used to develop new, unified model building codes for the United States. These digital maps integrate a wide range of geological and geophysical information to estimate the maximum severity of ground shaking that each given location is expected to experience in the coming decades. The USGS works closely with earthquake researchers, engineers, and State and local government representatives across the Nation to ensure the maps represent the most current and accurate information available. USGS science underlies the 2012 version of the International Building Code (IBC), the code that has been adopted throughout most of the United States as the standard for building design. In addition, work is underway to utilize the latest USGS hazards assessments in the upcoming 2018 update to the IBC.

Because the scale of the national seismic hazard maps precludes taking into account local variations in the size and duration of seismic shaking caused by small-scale geologic structures and soil conditions, the USGS also partners with State and local experts to produce more detailed urban seismic hazard maps for high- to moderate-risk areas. These products make it possible for local officials to make precise and informed zoning and building code decisions. Modeling of ground motion is also provided for engineering applications. In conjunction with release of these targeted products, the USGS conducts workshops to assure the proper transfer of knowledge and to help design effective mitigation strategies.

Key projects in assessment and characterization include:

National Seismic Hazard Maps – USGS scientists completed an extensive review process and delivered a new version of national hazard maps in 2014, which were last updated in 2008. The USGS also completed engineering design maps, derived from new hazard maps and adding specifications from the Building Seismic Safety Council (BSSC). The BSSC in turn incorporated the USGS design maps into new NEHRP Recommended Provisions, and is working to incorporate these maps into the 2016 construction engineering standards of the American Council on Seismic Engineering and the 2018

International Building Code. In 2015, the USGS will also produce and update a variety of other products derived from the seismic hazard map for use by engineers, city planners and other end-users. In addition, the USGS is working with State partners in several central U.S. States to create new types of seismic hazard models and maps that reflect changes in earthquake rates due to industrial activity such as petroleum extraction, and a suite of new hazard assessment products that meet the needs of State officials, private sector companies, and concerned communities.

Updated California Earthquake Model – The USGS has developed a new earthquake forecast for California in partnership with the California Geological Survey and the Southern California Earthquake Center (SCEC, a university research consortium). This rupture model, which incorporates new research on how stress in the earth's crust is released in earthquakes, underlies the California portion of the 2014 National Seismic Hazard maps. In 2014, the USGS also completed and released a special version of the model that addresses the evolution of seismic hazard over time, which the California Earthquake Authority will use to refine earthquake insurance premiums. In 2015, the USGS is developing a method for incorporating aftershocks into the California model, which will yield a new earthquake hazard forecast that provides situational awareness of hazards that may change on time scales of hours to months.

Monitoring and Reporting of Earthquake Activity and Crustal Deformation

Deployment of the Advanced National Seismic System (ANSS) is focused on expanding and improving the performance and integration of national, regional, and urban seismic monitoring networks in the United States. The system consists of a national ANSS Backbone network, the National Earthquake Information Center (NEIC), 13 partner-operated regional networks in areas of moderate-to-high seismic activity, and the National Engineering Strong Motion Project for monitoring earthquake shaking in structures.

At the end of 2013, the development of the ANSS was about 38 percent completed. The USGS and partners had installed a cumulative total of 2,746 ANSS earthquake monitoring stations, including 1,634 channels of data recorded in buildings and other structures. The network is capable of detecting almost all felt earthquakes in the United States, except in remote areas of Alaska. Thanks to substantial improvements to station coverage and methods for rapid analysis, the NEIC now typically reports on domestic earthquakes within minutes of their occurrence.

The NEIC provides information on potentially damaging earthquakes to the National Command Center; the White House; the Departments of Defense, Homeland Security (including FEMA), Transportation, Energy, and Interior; State offices for emergency services; numerous public and private infrastructure management centers (e.g., highways, railroads and pipelines); the news media; and the public. Rapid earthquake notifications are delivered by e-mail and text message to about 500,000 subscribers, and a suite of earthquake information products such as *ShakeMaps, Did You Feel It?*, rapid *PAGER* estimates of financial and human impacts, and scientific data are available on the EHP's Web site, which receives more than two million page-views daily. The USGS also provides near-real-time data to NOAA's tsunami warning centers, supporting tsunami monitoring in the Pacific Rim and disaster alerting in Alaska, Hawaii, Washington, California, and U.S. Territories in the Western Pacific and Caribbean.

Earthquake Early Warning – Earthquake Early Warning (EEW) is the capability to quickly and automatically identify and characterize an earthquake after it begins, calculate the intensity of ground shaking that is expected to result, and deliver warnings to people and systems that may experience damaging shaking in seconds or minutes. Recent Federal, State, and private investments have resulted in a demonstration EEW system called *ShakeAlert*, which has been sending live alerts to selected test users in California since January of 2012.

Before reliable public alerts can be sent, the system requires more ground-motion sensor stations and additional development to maximize its speed, reliability and accuracy. In 2015, Congress added $5.0 million to the fiscal-year 2015 budget of the USGS, *"to transition the earthquake early warning demonstration project into an operational capability on the West Coast."* The USGS will use this investment in 2015-16 to speed up alerts to accelerate development and testing of the system to a point that will allow limited implementation of some low-risk applications in areas where station density is sufficient.

EEW development continues to be closely coordinated with State and private partners. For example, in California the legislature recently passed Senate Bill 135, committing to developing a seismic early warning system. The California Office of Emergency Services is currently working with the USGS and other stakeholders to define standards, management structures, and a public education program for the system, and to identify non-Federal funding sources.

Regional Earthquake Monitoring – As part of the ANSS, the USGS and cooperating universities operate regional seismic networks in areas of high seismicity. Data from all U.S. seismic networks are used to monitor active faults and ground shaking, in much greater detail and accuracy than is possible with the national-scale network. Each region has appropriate local data processing capabilities; regional data are contributed to a new national ANSS catalog of earthquakes. ANSS regional networks serve as State or local distribution points for information about earthquakes to the public, local and State agencies, and other regional interests. The regional data centers also relay earthquake data in real time to the USGS NEIC, as well as to other regional networks. The centers provide information about regional earthquake hazards, risks, and accepted mitigation practices, and those centers located at universities provide training and research facilities for students.

To support partner activities in earthquake monitoring, approximately $6.2 million was provided in 2014 through cooperative agreements for regional seismic and geodetic networks, and structural and geotechnical arrays, operated by the following universities and States:

Seismic Monitoring Networks Supported by the USGS in 2014	
California Institute of Technology	University Nevada Reno
Columbia University, Lamont-Doherty Earth Observatory	University of Memphis
Montana Bureau of Mines and Geology	University of Oregon
Saint Louis University	University of South Carolina
University of Alaska Fairbanks	University of Utah
University of California Berkeley	University of Washington
University of California San Diego	

Geodetic Monitoring Networks Supported by the USGS in 2014	
Central Washington University	University of California San Diego
San Francisco State University	University of Memphis
University of California Berkeley	University of Nevada Reno

For 2015, funding for regional seismic and geodetic network operations remain a high priority, and will be directed toward ensuring robust regional network operations and maintenance.

Research into Earthquake Causes and Effects

The USGS conducts research on the causes, characteristics, and effects of earthquakes. This research has direct application in increasing the accuracy and precision of the agency's earthquake hazards assessments, earthquake forecasts, earthquake monitoring products, and earthquake mitigation practices.

Induced Seismicity – The development of underground oil and gas (UOG) resources has the potential to induce earthquakes, primarily through wastewater disposal. Researchers have long known that human actions can cause earthquake activity, from petroleum extraction to water reservoir impoundments and fluid injection into the subsurface. Although very small magnitude ("microseismic") events are commonly produced by hydraulic fracturing operations, current understanding suggests that the potential risk of felt or damaging earthquakes is greatest from high-volume wastewater disposal.

Although the risk of inducing felt seismic events directly stemming from hydraulic fracturing operations is believed to be low, there is concern that potentially hazardous seismic events can be induced through disposal of wastewater through underground injection control disposal-wells. Extensive sets of empirical observations could demonstrate that operations to date are consistent with predictive models over a range of geologic conditions and operational parameters. There is a need for more data and analysis to relate UOG operations to induced seismic events, to connect these events to specific operational parameters and geologic conditions, and to develop mitigation plans for decisionmakers, State regulators, and industry experts attempting to minimize seismic risks. The USGS is working with industry on case studies that will illuminate the factors controlling the phenomenon.

In 2013-2015, the USGS has responded to significant increases in earthquake rates in Oklahoma, Kansas and Texas, accompanied by moderate-magnitude, lightly damaging earthquakes. The additional funding for induced seismicity research that was appropriated by Congress in 2014 and 2015 is being used to develop methods to forecast which types of injections in which geologic setting would be likely to induce or trigger earthquakes, to perform comprehensive studies at carefully-selected field sites, and to establish procedures to adapt USGS National Seismic Hazard Maps to account for potential hazards from earthquakes induced in association with the production of oil and gas.

Forecasting Hazards from Earthquake Sequences – Earthquakes occur in sequences, typically a large event followed by many aftershocks, some of them large and potentially damaging. A large earthquake may also trigger the occurrence of additional earthquakes on nearby faults at a later time. The USGS is

engaged in research to quantify changes in earthquake likelihoods with time, in response to observations of the earthquake generation process from data such as earthquake catalogs or geodetic deformation.

New research and development efforts that began in 2012 will continue in the proposed 2016 Program plan. In 2015 and beyond, the USGS will develop, validate, and use state-of-the-art methods to—

- Produce a new product that generates time-dependent aftershock probabilities on-demand for large earthquakes.
- Develop a suite of new products useful to society, ranging from one-time earthquake forecasts, to new hazard assessment maps, continuously updated online releases, and user-customized estimates for decision support and situational awareness.
- Work in cooperation with international partners so that USGS forecasts of earthquake hazard in foreign countries are compatible with those made by authoritative sources in those countries. The products released abroad from these forecasts, however, need to be explored in more depth.

Eastern U.S. Earthquake Research and Monitoring – The USGS continues to work toward assessing the hazard posed by Eastern U.S. earthquakes. The goal of this research is to improve the seismic hazard criteria used in building codes, land-use decisions, and mitigation strategies to reflect regional earthquake potential and local near-surface sediment and soil conditions. In early 2015, the USGS will release a major series of peer-reviewed papers and reports summarizing findings from investigations of the 2011 magnitude 5.8 earthquake that caused damage in central Virginia and the District of Columbia.

In 2013, the National Science Foundation began a cooperative project to operate 150-200 of the Earthscope "Transportable Array" stations through 2018—this new network is called the Central and Eastern U.S. Seismic Network, or CEUSN. The network provides greatly improved earthquake detection and accuracy in the region that hosts most of the Nation's nuclear power reactors, and also in areas that have seen increased seismicity since 2009 (see induced seismicity, this section). In 2014 and 2015, of the funding appropriated to the EHP by Congress for improved ANSS products and monitoring in the Central and Eastern States, a portion is being used to extend NSF's investment, accelerating progress toward optimizing the deployment for USGS purposes. However, the USGS will need additional funding by 2018 to fully assume CEUSN operation as a permanent feature of the ANSS.

Supporting External Research Partnerships – External collaboration advances targeted research and addresses specific needs of the USGS using the experience and knowledge of world experts. The EHP provides competitive, peer-reviewed, external research support through competitive grants and cooperative agreements that enlist the talents and expertise of the academic community, State government, and the private sector.

External program activities include: mapping seismic hazards in urban areas; developing credible earthquake planning scenarios including loss estimates; defining the prehistoric record of large earthquakes; investigating the origins of earthquakes; improving methods for predicting earthquake effects; and testing the prototype system for an earthquake early warning system (see previous discussion). The USGS also has a cooperative agreement with the Southern California Earthquake Center (SCEC), a 40-institution research consortium funded by the USGS and the NSF. The following table lists

the institutions and agencies that received grants and cooperative agreements in 2013. The USGS anticipates that a similar number and range of partners will receive assistance in 2014.

USGS 2014 Grants for Earthquake Research and Hazard Assessments	
Association of Bay Area Governments	University of Cincinnati
Boston College	University of California Berkeley
Brigham Young University	University of California Davis
California Geological Survey	University of California Los Angeles
California Institute of Technology	University of California Riverside
California State Polytechnic University	University of California San Diego
California State University East Bay	University of California Santa Barbara
College of Charleston	University of Colorado
Consortium of Organizations for Strong-Motion Observation Systems	University of Illinois at Urbana-Champaign
Earthquake Engineering Research Institute	University of Kentucky
Georgia Institute of Technology	University of Memphis
Global Seismological Services	University of Missouri
Harvard University	University of Nevada Reno
Humboldt State University	University of New Hampshire
Indiana University	University of Rhode Island
International Seismological Centre	University of Southern California
Iowa State University	University of Texas Austin
Lettis Consultants International, Inc.	University of Utah
Massachusetts Institute of Technology	University of Vermont
Optim Seismic Data Solutions	University of Washington
Oregon State University	University of Wisconsin Madison
Princeton University	URS Corporation
Rutgers University	URS Group, Inc.
San Diego State University	Utah Geological Survey
Stanford University	Virginia Polytechnic Institute and State University
Tufts University	Western Washington University
Utah Geological Survey	Woods Hole Oceanographic Institution

Earthquake and Safety Information for Loss Reduction – The Earthquake Hazards Program produces a large (and growing) quantity of data and information on earthquakes and related hazards. For this science information to be effectively used to mitigate risk and limit losses, the USGS takes a proactive role with various user communities in the application and interpretation of program results. Active engagement with users provides opportunities for dialogue on modifications to USGS existing products and advice on new products that make USGS work and results more relevant and applicable. Opportunities for engaging users take place at both national and regional levels.

The National Earthquake Information Center, Golden, CO. With support from the President's tsunami warning initiative following the devastating Sumatra earthquake and tsunami of 2004, this center is staffed on a 24x7 basis and provides rapid information on damaging earthquakes for use in emergency response and aid delivery worldwide.

Improved Earthquake Information Products – The Earthquake Hazards Program (EHP) strives to create and refine a variety of earthquake

information products that accurately and effectively communicate earthquake science to key audiences, including decisionmakers. The EHP supports the USGS SAFRR project to improve sharing of earthquake safety information with the general public, conducting research with social scientists with expertise in risk communication. In 2014, experts are developing a consistent language and practices for communicating Earthquake Early Warning messages. In 2015, attention will turn to communicating seismic hazard information to non-technical users, including rapidly evolving information about aftershocks and other hazards following large earthquakes.

Activity: Natural Hazards
Subactivity: Volcano Hazards

2014 Actual: $23.1 million (138 FTE)
2015 Enacted: $25.1 million (140 FTE)
2016 Request: $25.7 million (141 FTE)

Overview

Volcanic eruptions are among the most destructive phenomena of nature, and even small events can have a significant social and economic impact. Unlike many other natural disasters however, volcanic eruptions can be predicted well in advance of their occurrence, providing the time needed to mitigate the worst of their effects. For example, in 2014 VHP scientists at the AVO successfully forecast an explosive eruption of Pavlof Volcano in Alaska and gave FAA and NWS advanced notice of the ensuing airborne volcanic ash. Also in 2014, VHP scientists at the HVO carefully monitored the progress of a 13 mile lava flow emanating from a vent on Kilauea volcano. The flow has already destroyed property and continues to threaten homes and other property in the Puna district (population ca. 45,000) on the Big Island of Hawaii. HVO has worked closely with local, State, and Federal emergency managers to provide these officials the information they need to manage the current crisis.

Despite these successes, the Nation's volcano monitoring infrastructure remains incomplete. Many volcanoes, including some of the most threatening, lack the instrumentation necessary for effective forecasting and have had only rudimentary geologic study. To address this monitoring gap, the VHP is implementing the National Volcano Early Warning System (NVEWS), a comprehensive effort to ensure that all of the Nation's volcanoes possess a level of monitoring commensurate with the threat they pose. NVEWS is far more than a plan for deploying instruments – it envisages a systematic approach to volcano monitoring designed around the idea that effective mitigation of volcanic hazards requires coordinated study and action across a broad front.

The VHP works closely with other Federal agencies including the NOAA, NSF, NASA, NGA, FAA, and DOD. In most cases, the information transfer is two way. The VHP provides interpretive products about volcanic activity to these agencies, while also receiving from them an abundance of data useful for volcano monitoring. Interagency cooperation of this sort is critical to success of NVEWS, which emphasizes both external partnerships and the need for data from a variety of instrument types.

The VHP is built around a structure of volcano observatories that divide the Nation's volcanoes into distinct areas of responsibility:

- Hawaiian Volcano Observatory – Hawaii
- Cascades Volcano Observatory – Idaho, Oregon, and Washington
- Alaska Volcano Observatory – Alaska and the Commonwealth of the Northern Mariana Islands

- California Volcano Observatory – California and Nevada
- Yellowstone Volcano Observatory – Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming

Under the NVEWS model, the observatories retain considerable independence, recognizing the supreme importance of local knowledge and close ties with local officials. NVEWS also places great value on interoperability among the observatories, ensuring that they all use a common set of tools and standards. Ideally, the observatory structure balances the benefits of centralization against the realities of local differences. Each observatory is responsible for volcano monitoring, community preparedness, managing volcanic crises, and coordinating research in their areas of responsibility.

Program Performance

Response to Eruption and Volcanic Unrest

Cleveland – The most active volcano in Alaska at present, Cleveland Volcano remained at an elevated level of unrest throughout 2014, producing several low-level ash emissions. The Aviation Color Code was YELLOW throughout the year except for brief period in early January when intensifying activity prompted a rise to ORANGE.

Kilauea – Kilauea volcano has been in continuous eruption for more than 32 years and the June 27th lava flow is the first flow to threaten a residential area since 2011. The HVO continuously monitors this eruption by tracking the lava flow and analyzing data from seismometers, thermal imagers, webcams, GPS receivers, and gas measuring instruments. The HVO makes frequent helicopter overflights to map the lava flow and to facilitate field investigations by observatory staff. The USGS works closely with Hawaii County Civil Defense and the Hawaii County Mayor's Office to provide updated information on lava flow activity, including predicted flow paths and advance rates. Since August 24, 2014, HVO scientists have participated in daily Town Hall Meetings with Hawaii County Civil Defense representatives and, through a program of vigorous community outreach, have connected directly with several thousand Pahoa Village residents.

Long Valley Caldera – Long Valley Caldera in California, near the resort town of Mammoth Lakes, has entered a period of renewed volcanic unrest with increased seismicity and uplift of the central resurgent dome of about one inch per year. The VHP responded to three earthquake swarms at Long Valley in 2014, including a relatively energetic swarm September 25-26 in the southeastern caldera. This swarm, which included multiple earthquakes of M 3.5, was the largest swarm in the caldera since 1997. As such, it generated considerable regional and national media interest, with VHP scientists participating in numerous interviews.

Mount St. Helens – In April 2014, the Cascades Volcano Observatory announced that Mount St. Helens remains active and is showing signs of long-term uplift and earthquake activity. Re-pressurization of a volcano's magma reservoir is commonly observed at other volcanoes that have erupted recently, and this

can continue for many years without an eruption. Mount St. Helens is the most active volcano in the continental United States.

Pavlof – In June and November 2014, Pavlof Volcano in Alaska erupted violently, producing ash plumes rising to more than 30,000 feet above sea level, prompting AVO to raise the Aviation Color Code to RED. Prior to this, the last time an Alaska Volcano had been at RED was in 2009 during the Redoubt eruption. The 2014 Pavlof eruptions caused the cancellation of dozens of flights in southern Alaska while also delighting the residents of Cold Bay with spectacular lava fountains.

Shishaldin – Throughout most of 2014, Shishaldin Volcano has been in a state of low-level eruption, with the effects mostly confined to the summit crater. The aviation color code has remained at ORANGE.

Yellowstone – Beginning in late 2013, and continuing into the second half of 2014, Yellowstone caldera experienced an unusual episode of ground deformation centered near the Norris Geyser Basin. Consisting first of uplift, the deformation abruptly turned to subsidence immediately following a M4.8 earthquake, also centered near Norris. This earthquake, the largest in Yellowstone in 30 years, was widely felt throughout the Park and generated considerable media and public interest. VHP scientists gave many interviews and several scientific presentations about the unusual deformation and earthquake emphasizing that although scientifically interesting, these events do not imply an increased likelihood of eruption.

Response to Landslide near Oso, WA

VHP scientists with expertise in landslides and landside modeling participated in the SR530 (Oso) landslide response. These scientists worked extensive hours for several weeks following the disaster to provide technical assistance, conduct preliminary assessments of the slide, produce landslide models, and install real-time monitoring instruments to support the search, rescue and recovery teams who were working on the landslide in the weeks following the March 22, 2014, event. Seven VHP scientists were awarded the U.S. Geological Survey's Director's Award in recognition of and in appreciation for their contributions to the SR530 landslide (Oso, WA) response.

NVEWS Progress

- The Alaska Volcano Observatory installed two seismic stations, two infrasound stations, and a Web camera on Cleveland volcano in the Aleutians, and conducted reconnaissance-level geologic mapping there as well. The combination of the geologic investigation and the new instrumentation network goes a long way to closing the monitoring gap at this persistently active volcano. The VHP worked in collaboration with the NSF-funded Anthropology and Polar Programs project, thereby reducing costs and enhancing the safety of field investigators excavating a human antiquities site nearby.
- The VHP in partnership with the other USGS programs and the U.S. Forest Service began a LiDAR survey of Glacier Peak, a Very High Threat volcano in Washington. The survey is 78 percent complete and will finish in summer 2015. Lidar data will greatly accelerate geologic mapping efforts and also provides information useful for monitoring network design. At present,

Glacier Peak has essentially no ground-based instrumentation. This Lidar survey is a first step toward closing the sizeable monitoring gap at this dangerous volcano.

- Two new seismometers were installed on Mount Hood, a Very High Threat Volcano about 45 miles east of Portland, OR. Although these new instruments improve monitoring capabilities at Mount Hood markedly, the volcano still remains significantly under-monitored.
- The VHP developed a fiscally sustainable plan for operating existing monitoring networks on High and Very High Threat volcanoes in Alaska. The plan involves upgrading telemetry at the networks from analog to digital, thereby achieving increased performance, reliability, and lower annual maintenance costs. The upgrade will also bring the VHP into compliance with changing Federal Communications Commission regulations over radio spectrum allocation.
- HVO scientist Weston Thelen published (SIR 2014-5179) a comprehensive seismic instrumentation plan for Hawaii's six active volcanoes. This plan assesses the current state of HVO's seismic network and calculates the number and type of additional instruments needed to provide a level of seismic monitoring commensurate with the risks these volcanoes pose. It also provides cost estimates for both the installation and maintenance of the improved network.
- VHP scientists completed a USGS Professional Paper on the "Postglacial eruptive history, geochemistry, and recent seismicity of Aniakchak volcano, Alaska Peninsula." Aniakchak is a High Threat Volcano with a good instrumentation network. With, the addition of this new geological study, Aniakchak is now a well-monitored volcano.

Technical Accomplishments

- **AshCam**. At the behest of the National Weather Service (NWS), the VHP developed a Web-based application, called "AshCam" that aggregates webcam imagery useful for tracking the propagation of volcanic ash plumes. The application allows scientists to easily create movies from a series of images and also has a variety of tools to assist collaboration across geographically separate locales.
- **Ash3D**. Ash3D is VHP-developed software designed to track airborne volcanic ash plumes and estimate potential ash fall accumulation. In early 2014, the VHP declared the Ash3D system fully operational and began offering access to external collaborators. To ensure high reliability, the system consists of two independent servers; one operated in Vancouver, WA, the other in Anchorage, AK. To date, the Ash3D system has more than 100 users from scientific organizations across the globe, including NWS and the Air Force Weather Agency.
- **Lava flow modeling**. The VHP has committed to improve lava flow inundation modeling through partnership with the *Instituto Nazionale di Geofisica e Vulcanologia* (INGV) of Italy with application toward future eruptions in Hawaii, the Southwestern United States, and support of the USGS-Saudi Geological Survey joint project to produce a volcanic hazard assessment for the Harrat Rahat volcanic field in the Kingdom of Saudi Arabia.

Scientific Products

In 2014, VHP scientists published more than 80 peer-reviews scholarly articles. Among the highlights are a pair of papers by David George and Richard Iverson on modeling debris flows, both published in the *Proceedings of the Royal Society*, a paper by Jacob Lowenstern and colleagues about radiogenic helium at Yellowstone published in *Nature*, and a paper by Don Swanson and colleagues about the potential for explosive eruptions at Kilauea volcano published in *Geology*. Other notable accomplishments achieved in collaboration with external partners include the "Alaska interagency operating plan for volcanic ash episodes" prepared by AVO, ADHSES, FAA, NWS, AFWA, USCG, and ADEC, and the "Old Faithful Science Review Panel: Hydrogeology of the Old Faithful area, Yellowstone National Park, Wyoming" prepared in cooperation with YNP.

Public Communication and Community Preparedness

The VHP uses an array of Internet-based technologies as the primary tools to inform the public of volcanic activity, to confirm that no activity is occurring, and to educate about volcano science. The VHP has completed a reengineering of its back-end Web site infrastructure, and 75 percent of the public-facing suite of Web sites has undergone content redevelopment. This Web-presence overhaul aims to provide better and timelier information about volcanoes and related hazards to the public and USGS partner agencies, and to do so reliably under conditions of very high demand (e.g., during volcanic unrest). The highly-successful Volcano Notification Service (VNS), a free e-mail and text messaging service that sends customized notifications about the status of volcanic activity and other significant events at volcanoes in the United States, has grown to include 10,000 subscribers since its inception in September 2012. The VHP also publishes volcano activity information and timely volcano science via several social media channels in order to meet the ever-growing public demand to receive information in their own "news feeds." In 2015, the VHP will finish the upgrade and redesign of its Web presence, thereby freeing resources to explore new technologies that will improve our ability to disseminate notifications and forecasts quickly. Implementation of Common Alerting Protocol (CAP), which will automatically disseminate local and standardized volcanic activity alerts via communication systems (e.g., cellular networks), is in the future plan as well as expansion of the VHP's social media offerings.

International Efforts

The Volcano Disaster Assistance Program (VDAP), a joint project with USAID Office of Foreign Disaster Assistance (OFDA), continues to build monitoring infrastructure and crisis response capacity in Latin America and the Western Pacific regions, including new project work in Indonesia, Papua New Guinea, Colombia, Peru and other Latin American countries. The VDAP is supported by the USAID's Office of Foreign Disaster Assistance and brings important hazard mitigation lessons home for use in the United States, such as utilizing international eruption experience to improve forecasting of eruptions. Noteworthy 2014-2015 VDAP activities include crisis responses to unrest and eruptions in Indonesia, Guatemala and Colombia. The VDAP continues to assist the Indonesian government's Center for Volcanology and Geologic Hazard Mitigation (CVGHM) in responding to the ongoing eruption of Sinabung volcano in northern Sumatra, where thousands of people have been repeatedly evacuated because of explosive activity and lethal pyroclastic flows. Similarly, during 2014, VDAP helped the I*nstituto Nacional de Sismologia, Vulcanologia, Meteorologia y Hidrologia* (INSIVUMEH) forecast eruptions and issue warnings at Fuego volcano during its largest eruption in 20 years. The VDAP is also

currently assisting the *Servicio Geologico Colombino* deal with a prolonged seismic crisis at Chiles volcano, located along the Colombia-Ecuador border. All VDAP international responses follow requests from foreign governments, which are evaluated by the Department of State and OFDA in terms of humanitarian benefit and U.S. foreign policy. In addition to the response work, during 2014 VDAP assisted CVGHM plan the September 2014 Cities on Volcanoes meeting in Yogyakarta, Indonesia, which brought together more than 900 international scientists and emergency managers to share experiences and develop best practices for volcanic hazard mitigation. During the COV meeting, the USGS and CVGHM signed an Annex to the Memorandum of Understanding between the Republic of Indonesia and the United States for General Cooperation in Science and Technology. The Annex extends the VDAP-CVGHM partnership through 2019.

The USGS has reestablished its prior longstanding collaboration with the Saudi Geological Survey (SGS, formerly Directorate of Mineral Resources) through an agreement to conduct a five-year study of the volcanic and volcano-tectonic hazards to the city of Al Madinah. The project is funded by the SGS and involves determining the eruptive history and eruptive style of the northern portion of the adjacent Harrat Rahat volcanic field through detailed geologic mapping and geochronology, performing computer estimations of the dispersal of ash and the inundation areas of lava flows from likely future eruptions, surveying the volcanic field and adjacent areas by gravity and other geophysical methods to reveal subsurface structures including faults and the presence of magma (molten rock), estimation of the likely magnitude of shaking in Al Madinah by earthquakes, and capacity building for the SGS through training both in Saudi Arabia and in the United States. The USGS portion of the project is based at the Menlo Park, CA, office, and includes staff from the California Volcano Observatory, the Earthquake Science Center, and the Geology, Minerals, Energy, and Geophysics Science Center. Other participating USGS staff are based at the Cascades, Alaska, and Hawaii Volcano Observatories, and the Crustal Geophysics and Geochemistry Science Center, Denver, CO. Products will be geologic and geophysical maps and reports on scientific findings and on assessed hazards. Agreed-to annual funding to the USGS is approximately $2 million, and the project is early in its second full year.

Collaboration with National Science Foundation (NSF)

The USGS is a major participant in the NSF's $5 million per year GeoPRISMS (Geodynamic Processes at Rifting and Subducting Margins) Program, which will study the geology and geophysics of continental margins, focusing on the Cascadia and the Alaskan-Aleutian subduction zones. VHP scientists worked closely with their academic partners to secure $3 million in GeoPRISMS funding for a "slab-to-surface" geophysical and geochemical imaging effort at Mount St. Helens. Similar collaborative research opportunities for projects in the Alaskan-Aleutian subduction zone were initiated in 2014 at Cleveland volcano in the Aleutians, and will continue into 2015 and 2016.

The VHP is also involved with a type II proposal to the Hazards section of National Science Foundation's Science, Engineering and Education for Sustainability (SEES) portfolio. The proposal, called "Persistent Volcanic Crises – Resilience in the Face of Prolonged and Uncertain Risk," seeks to understand the full spectrum of volcanic unrest from its physical origins to its societal consequences.

The USGS participated in a NSF-funded workshop in September 2014 that sought to address the end of the Earthscope initiative in 2018. The VHP and other parts of the USGS depend on hundreds of

instruments deployed as part of Earthscope and their disappearance would represent a major step backward for monitoring capabilities at many U.S. volcanoes. Discussions with NSF and other stakeholders in Earthscope instrumentation will continue in 2015 and 2016 with the goal of finding some means of funding to keep these instruments functional past their 2018 sunset date.

Planned Accomplishments – 2015

- Continue response to Kilauea's "June 27th" lava flow, with mapping augmented by georeferenced satellite imagery. HVO scientists will continue to conduct helicopter overflights in support of field investigations and continue modeling of flow advancement for forecasts of estimated time of arrival to threatened communities still vulnerable to lava flow advancement.
- Complete the high-resolution Lidar survey of Glacier Peak Washington, in support of ongoing geologic field investigations and preparation of a new geologic map of the volcano and hazard assessment.
- Begin the permitting process for a new instrumentation network on Glacier Peak, a very High Threat volcano in Washington. This process, conducted in partnership with the U.S. Forest Service, will continue for the next several years.
- With new funds from Congress, the VHP will begin implementing its new plan for fiscally sustainable operation and maintenance of existing monitoring networks on High and Very High Threat volcanoes in Alaska and the Commonwealth of the Northern Mariana Islands.
- With permit pending, the VHP will augment the small existing instrumentation network on Mount Hood, a Very High Threat volcano in Oregon.
- Update the National Volcano Early Warning System threat rankings, hazard exposure, and level of monitoring reports: the "Chronology and References of Volcanic Eruptions and Selected Unrest in the United States, 1980-2008.
- CalVO will undertake a bi-national exchange of scientists, civil authorities, and emergency managers from Chile. Similarities in the nature of the hazards posed at Long Valley volcanic region (eastern California) and Chaitén (northern Patagonia) provide opportunities for scientists and civil authorities to learn from one another and strengthen risk reduction in their home countries.
- In collaboration with the California Office of Emergency Services, CalVO is preparing a comprehensive assessment of the State's exposure to volcanic hazards. Exposure of various populations, assets, and natural resources within designated volcano-hazard zones are being quantified from stakeholder elicitations and analysis of regional datasets using geographic-information-system (GIS) tools. The report will be released in early 2016.
- In early 2015, the HVO will implement operational volcanic tremor detection and location in real time. Volcanic tremor is often a harbinger of imminent eruption. Using newly developed algorithms, the tremor detection system notifies scientists when tremor occurs.
- The HVO will work toward a better understanding the relationship between Kilauea's profoundly high summit eruptive gas emission rates and exposure of downwind communities and agriculture to associated health and environmental impacts.

Planned Accomplishments – 2016

- Following the NVEWS plan, grow and improve the Nation's volcano monitoring infrastructure. Targets for growth include Glacier Peak, WA, Mount Hood, OR, and Mount Shasta, CA. With permits pending, we aim to install or augment instrumentation on all three of these Very High Threat volcanoes.
- The VHP will work in partnership with USGS Geothermal Program and Water Resources Program to assess geothermal potential of prospective volcanic areas and to conduct field investigations and modeling of geothermal systems and preparation of updated hazards assessments at potential geothermal production sites at Akutan in AK, Salton Buttes, in CA, and on the island of Hawaii.
- Continue to improve maintenance on instrumentation networks on High-Threat Alaskan volcanoes, redesigning these networks for higher reliability where possible.
- Continue geologic investigations at Glacier Peak, WA, and Mount Shasta, CA, in support of new hazard assessments for these Very High Threat volcanoes.

Activity: Natural Hazards
Subactivity: Landslide Hazards

2014 Actual: $3.5 million (19 FTE)
2015 Enacted: $3.5 million (19 FTE)
2016 Request: $4.0 million (21 FTE)

Overview

Landslides occur in all 50 States and around the world in mountainous and hilly areas. Where landslides interact with human activities, lives may be lost and property and infrastructure damaged. Landslides triggered by heavy rainfall can impact broad regions. For example, landslides occurred over an area of 1,300 square miles in the Colorado Front Range as a result of heavy rainfall in early September 2013. Isolated landslides such as those in western Colorado and Washington State may occur without obvious triggers, yet travel long distances with tragic consequences. The Landslide Hazards Program (LHP) conducts targeted research to understand landslide initiation and mobility processes. This understanding is used to develop methods and models for landslide hazard assessment, develop and deploy systems to monitor threatening landslides, and to develop methods and tools for landslide early warning and situational awareness. Program activities are targeted towards the types of landslides that result in human and economic losses in the United States such as those with long travel distances, those initiated by heavy rainfall, and those exacerbated by the effects of wildfire.

USGS scientists respond to landslide emergencies and disasters nationwide. Federal, State, and local agencies are assisted through landslide site evaluations and are provided strategies for reducing ongoing and future impacts from landslides. USGS expertise is called upon when landslide disasters occur abroad. The USGS works with the USAID OFDA to respond to appeals for technical assistance from affected countries.

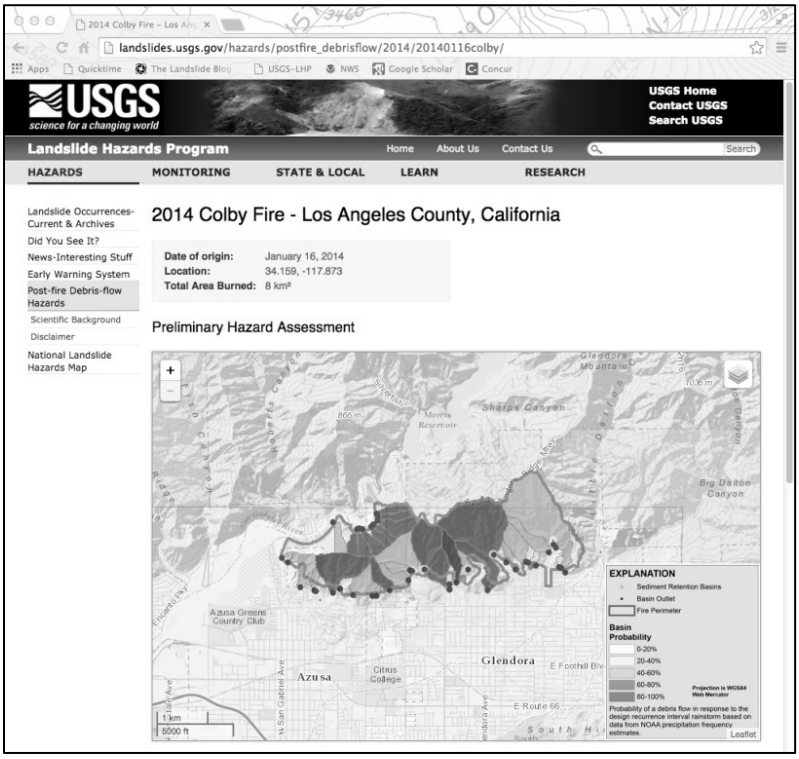
The USGS deploys near-real-time monitoring systems at active landslide sites to gather continuous movement, rainfall, soil-moisture, and pore-pressure data needed to understand the mechanisms of landslide occurrence and mobility. Such understanding can form the scientific underpinnings for early warning of conditions that may trigger landslides. For example, the LHP works in conjunction with the National Weather Service (NWS) to issue advisories regarding the potential for debris-flows (potentially deadly and destructive, fast-moving landslides) in areas of southern California recently burned by wildfire. Data needed to extend these methods to other parts of the Western United States affected by wildfire are being collected.

Consistent with the Department of Interior goal to protect lives, resources, and property by providing information to assist communities in managing risks from natural hazards, the USGS provides timely information through the National Landslide Information Center (NLIC). The Center communicates with the public about current emergency responses and provides information to the external user-community through fact sheets, books, reports, and press releases.

Program Performance

Primary LHP activities include conducting landslide hazard assessments, landslide monitoring, and disseminating landslide information.

Landslide Hazard Assessment Activities – Garden-variety rainstorms can initiate debris flows from steep hillsides recently burned by wildfire. In 2014, the LHP moved delivery of post-wildfire hazard assessments to a Web-based system. The shift in delivery method was in response to requests from Burned Area Emergency Response (BAER) teams and emergency managers to deliver information in timely manner in a format that can be readily ingested into data systems they use. This year hazard assessments were conducted for about 15 major wildfires in the Western United States and results were made available to the public, the U.S. Forest Service (USFS), the NWS, and local county emergency response, public works, and flood control agencies within a few days after burn severity data became available. Previously, hazard assessments took about one month to complete. This change in delivery procedure represents a 90 percent reduction in the time to produce and deliver a hazard assessment.



Web-based system for delivery of post-wildfire debris-flow hazard assessments. The LHP now delivers hazard assessments using a public-facing Web page. The webpage provides an interactive map viewer to display hazard assessment results along with links to download Geographic Information System (GIS) data for use by emergency mangers and BAER teams.

On March 22, 2014, a large, rapidly moving landslide impacted the community of Steelhead Haven, near Oso, WA, causing the deaths of 43 people. The LHP played significant roles in supporting the response to the disaster. The USGS dispatched a team to assess the potential for additional landslide activity to

affect search, rescue, and recovery operations, which at their peak, involved hundreds of professionals and volunteers. The USGS team provided expertise to search operations and assisted Snohomish County and Washington State in establishing a system to monitor and assess landslide stability in near real time. The system was operated by personnel both onsite and remotely for five weeks, seven days a week, during daylight hours until active search operations ended on April 28, 2014. During this time, no additional landslide activity impacted search operations.

The LHP provides susceptibility maps, hazard assessments, and situational awareness to a broad range of Federal and State agencies ranging from the USFS to emergency managers of local communities. These jurisdictions use USGS products to mitigate the effects of landslides and debris flows through land use planning, response planning, and warning systems. In 2015 and 2016, the LHP will continue to provide information to counties and other jurisdictions in Oregon, California, Colorado, Pennsylvania, New York, Tennessee, Washington State, and to Interior land management and other Federal agencies. These agencies will incorporate LHP information and products into emergency response and land-use plans and warning systems. The LHP will expend considerable effort in 2015 and 2016 to understand two long run out landslides that occurred in 2014, the Oso landslide in Washington State and the West Salt Creek landslide in western Colorado. Because landslides that run out long distances travel at high speed, their impact can be great as demonstrated in the case the Oso landslide. The LHP will also continue to focus considerable effort on the landslides triggered by the record-breaking September of 2013 rainstorm in the Colorado Front Range. Work begun in 2014 to map, characterize and understand the causes and conditions that contributed to the more than 1,000 landslides and debris flows that occurred during this storm will continue in 2015. These landslides caused significant damage to property and infrastructure, and killed three people. The LHP will work closely with county emergency managers, the USFS, and the National Center for Atmospheric Research (NCAR) in this effort.

In 2014, the LHP published a number of research publications with a broad range of applications and potential impact including: (1) reports documenting widespread debris flows from the September 2013 rainstorm in the Colorado Front Range; (2) studies on the physical properties of landslide materials and their effect on landslide hydrology and potential reactivation by earthquakes; (3) report on engaging the public in identifying landslides; (4) a study describing an improved model for predicting debris flow volume; and (5) a study describing field observations and models for debris flows generated by runoff processes, which are particularly important for poorly vegetated areas, such as those burned by wildfire.

Landslide Monitoring Activities – Sustained efforts in landslide monitoring have led to significant advances in understanding slope stability and landslide processes. Capability built by these efforts in cooperation with the USGS Volcano Hazards Program provided the expertise and experience needed to deploy and operate the near-real-time hazard assessment system used to support the search, rescue, and recovery operation at the Oso landslide.

In 2015 and 2016, the LHP will continue to collect data to develop rainfall thresholds for areas burned by wildfire in the intermountain States that will enhance the predictive capabilities of the joint NOAA/USGS early warning system. Monitoring of hydrologic conditions and landslide response to precipitation will provide the necessary understanding to develop improved hazard assessments, models, and early-warning criteria for landslide-prone areas in western Oregon, the Ferguson landslide near Yosemite National Park,

along U.S. Highway 50 in California, in recently burned areas of southern California, and at Chalk Cliffs in Colorado.

In 2015 and 2016, the LHP will expand and improve our post-fire debris flow warning system. Improvements made in 2014 to move post-fire debris-flow hazard assessments to a Web-based system will be enhanced by testing the applicability of models developed for the arid Southwestern United States to other parts of the country. Wildfires in eastern Washington State and other parts of the Pacific Northwest provide an opportunity to better understand post-wildfire debris flows in these climatic settings, and efforts in 2015 and 2016 will build on preliminary rainfall monitoring begun in 2014. The partnership with the NWS to issue post-fire debris-flow early warning will also be expanded to expand interactions with Weather Forecast Offices in Arizona and Colorado.

Landslide Information Dissemination Activities – The LHP will continue to respond to inquiries from the public, educators, and public officials on hazard mitigation, preparedness and avoidance strategies for landslide hazards through the National Landslide Information Center (NLIC). The NLIC will continue to provide leadership for the National Landslide Hazard Exchange Group, a group of landslide experts from the USGS and State geological surveys who are striving to create an inventory of landslides in the United States.

In 2012, the LHP launched a new Web site called "*Did You See It,*" which allows citizens to report landslides that then become part of a national inventory. The USGS hopes that this new interactive citizen-science initiative will go far in educating the public about landslide hazards, as well as eventually contributing vital data to the national inventory of landslides.

Activity: Natural Hazards
Subactivity: Global Seismographic Network

2014 Actual: $4.9 million (11 FTE)
2015 Enacted: $4.9 million (11 FTE)
2016 Request: $9.8 million (13 FTE)

Overview

The Global Seismographic Network (GSN) provides high-quality seismic data needed for earthquake alerts and situational awareness products, tsunami warnings, national security (through nuclear test ban treaty monitoring and research), hazard assessments and earthquake loss reduction, as well as research on earthquake sources, and the structure and dynamics of the Earth. The GSN is a joint program between the USGS and the National Science Foundation (NSF), and is implemented by the USGS, the Institute for Geophysics and Planetary Physics (IGPP) of the University of California at San Diego, and the Incorporated Research Institutions for Seismology (IRIS, a consortium of universities). The network currently consists of more than 150 globally distributed seismic stations, installed over two decades by the USGS and the IGPP.

Network operation is accomplished in cooperation with international partners who, in most cases, provide facilities to shelter the instruments and personnel to oversee the security and operation of each station. USGS responsibilities include station maintenance and upgrades, overseeing telecommunications, troubleshooting problems and providing major repairs, conducting routine service visits, training station operators, providing limited financial aid in support of station operations at sites lacking a host organization, and ensuring data quality and completeness.

Because of its real-time data delivery, the GSN has become a critical element of USGS hazard alerting activities, as well as the tsunami warning system operated by the National Weather Service of NOAA. Ninety-seven percent of GSN stations transmit real-time data continuously to the USGS National Earthquake Information Center in Golden, CO, and NOAA Tsunami Warning Centers in Hawaii and Alaska, where they are used to rapidly determine the locations, depths, magnitudes, and other parameters of earthquakes worldwide, in conjunction with data from other networks. The high quality of GSN data allows for the rapid determination of the location and orientation of the fault that caused the earthquake, and provides an estimate of the length of the fault that ruptured during the earthquake. These parameters are essential for modeling earthquake effects.

An additional important aspect of GSN activities is evaluating, developing, and advancing new technologies for seismic instrumentation, sensor installation, and data acquisition and management. Stations with unusually high background noise are relocated to quieter sites or configurations (e.g., burying sensors in boreholes, holes drilled or dug into the subsurface) to improve performance so that smaller events (earthquakes or explosions) or other signals of interest may be detected. Between 2010

and 2013, the USGS and its partners upgraded and standardized more than 130 GSN stations, reducing operating costs-per-station and building future operating efficiencies into the network.

All GSN data are available to the public and scientists around the world via the IRIS Data Management Center (DMC). Data from the GSN are used extensively for basic and applied research on earthquakes, Earth structure, and other geophysical problems, in studies conducted and supported by the USGS and agencies such as the NSF, the U.S. Department of Energy, and the U.S. Air Force.

Program Performance

The USGS is currently leading a multi-agency effort to develop and procure new borehole sensors, as part of ongoing efforts to maintain and improve the GSN. In 2014, in order to maximize the benefits of the new sensors, the team also performed an evaluation of tradeoffs of station noise versus sensor deployment depth. In addition, the development of software to automatically assess GSN data quality and to identify and diagnose performance issues is continuing, and has resulted in higher data quality for USGS operated GSN stations.

In 2015, the USGS will:

- Continue to operate the 100-station, USGS portion of the GSN at a high level of data recovery, real-time telemetry performance, and high cost efficiency.
- Begin evaluation of new GSN sensors being procured as part of a research and development procurement initiated in 2015, with funds provided by the Department of Energy.
- Work with partners such as IRIS, the U.S. Air Force, the Comprehensive Nuclear Test Ban Treaty Organization, and the International Federation of Digital Seismographic Networks, to improve the efficiency of station operations and reduce maintenance costs.

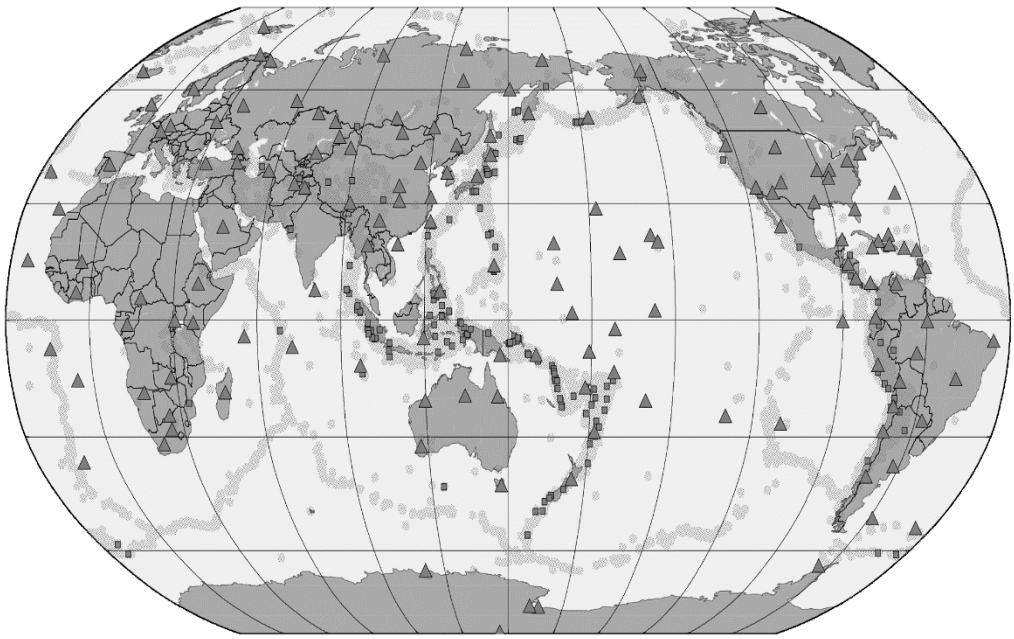
In 2016, the USGS will:

- Continue to operate the 100-station, USGS portion of the GSN at a high level of data recovery, real-time telemetry performance, and high cost efficiency.
- In anticipation of the new borehole sensors, begin a five-year effort to refurbish the civil works and site infrastructure at 10 GSN station sites, in order to reduce noise, improve security, and protect installed equipment. The needed improvements to the physical infrastructure at the sites are deferred maintenance tasks, such as re-drilling compromised boreholes, that have been prioritized by the advisory committee and are necessary to fully benefit from the new instrumentation.
- Begin a five-year effort to test, deploy, and install the borehole sensors procured under the research and development contract.

The GSN funding request will be used to refresh, support, and maintain the network at a high level of quality and reliability in future years.

Other Agency programs will continue to be supported through this effort, including:

- The NOAA Tsunami Warning Program and National Tsunami Hazard Reduction Program.
- The U.S. Air Force and Department of Energy nuclear test monitoring research programs.
- NSF projects that use GSN data for basic research on Earth structure and dynamics, seismic wave propagation, earthquake source complexity, and climate change.



Global Seismic Network stations (triangles) are shown against a backdrop of large earthquakes from 2000–2010 (circles—magnitude 6–6.9, squares—magnitude 7 and larger earthquakes).

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Activity: Natural Hazards
Subactivity: Geomagnetism

2014 Actual: $1.9 million (12 FTE)
2015 Enacted: $1.9 million (12 FTE)
2016 Request: $3.6 million (15 FTE)

Overview

Magnetic storms are caused by the dynamic interaction of the Earth's magnetic field with the Sun. While magnetic storms often produce beautiful auroral lights that can be seen at high latitude, they can also wreak havoc on the infrastructure and activities of our modern, technologically based society. Large storms can induce voltage surges in electric-power grids, causing blackouts, cause the loss of radio communication, reduce GPS accuracy, damage satellite electronics and affect satellite operations, enhance radiation levels for astronauts and high-altitude pilots, and interfere with directional drilling for oil and gas.

In order to understand and mitigate geomagnetic hazards, the USGS Geomagnetism Program monitors and analyzes the Earth's dynamic magnetic field. The Program is an integral part of the U.S. National Space Weather Program (NSWP), an interagency collaboration that includes programs in the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). The Geomagnetism Program provides data to the NSWP agencies, oil drilling services companies, geophysical surveying companies, and several international agencies. The Program also provides services to the electric-power industry.

Program Performance

Activities of the USGS Geomagnetism Program include operating geomagnetic observatories, managing data and developing magnetic products, and conducting scientific research. These activities will continue in 2016, with an emphasis on mitigating the consequences of large geomagnetic storms.

Geomagnetic Observatory Operations

The USGS operates 14 magnetic observatories across the United States and its territories. Data are collected continuously from each observatory by sensor systems that are operated in carefully controlled conditions to ensure long-term measurement accuracy. Data are transmitted in real time to the project's headquarters in Golden, CO, via a set of satellite and internet linkages. Ongoing operational system upgrades will benefit users through improved data quality, availability and timeliness.

Within this program element, 2016 performance will build upon the following 2014 and 2015 accomplishments:

- Continue collaboration with Natural Resources Canada for a joint instrument calibration facility at the USGS Boulder, CO, observatory.
- Complete testing and analysis of a newly designed "ObsRio" data acquisition system. With its low power requirements and high real-time operational reliability, this critical system will deploy as a replacement for existing Windows-based acquisition systems in 2015 and 2016.

The locations of the USGS geomagnetic observatories, with three-letter abbreviations of the observatory names.

- E-field monitoring: Deployment of magnetotelluric sensors to support validation of ground conductivity models used by the North American Electric Reliability Corporation (NERC) and the operators of the bulk power system.
- Completion of a new operations building at the Fresno Observatory, which will significantly improve the operational condition of the Fresno data acquisition system.

Data Management and Product Development

Observatory data are transmitted to the headquarters of the USGS Geomagnetism Program in Golden, CO. From there, they are processed and organized for prompt transmission to the NOAA Space Weather Prediction Center (SWPC), the Air Force Weather Agency (AFWA), and the NASA Goddard Space Flight Center; data are also transmitted to a number of foreign space weather agencies and to private companies in the United States. Auxiliary calibration measurements are combined with real-time data time series to produce accurate definitive data. These are used for constructing maps of the geomagnetic field and for analysis of long-term changes in geomagnetic activity. USGS data products are available through INTERMAGNET and through the Program's Web site (*geomag.usgs.gov*).

Within this program element, 2016 performance will build upon the following 2014 and 2015 accomplishments:

- Completion of major operational software components for improved methods of Web-based display and calibration and processing of magnetic data.
- Transition to a centralized database for all real-time and historical magnetic data, and development of a robust public-facing user-interface for accessing this data.

- Development, testing, and deployment of an industrialized MXE computer to replace outdated acquisition computers at the observatories.

Scientific and Applications Research

The USGS Geomagnetism Program conducts research to better understand basic physical processes and effects of geomagnetic hazards. In response to recent heightened concern for the security of the Nation's electrical power-grid infrastructure, USGS staff have been developing methods for estimating, in real time, the storm-time induction of electric fields in the Earth's crust and regional electric field estimates. This work is being conducted in collaboration with the Colorado School of Mines, the USGS Crustal Geophysics and Geochemistry Science Center, the NOAA/SWPC, and the NASA Community Coordinated Modeling Center.

Within this program element, 2016 performance will build upon the following 2014 and 2015 accomplishments:

- Initiating a test deployment of Spherical Elementary Current System (SECS) research model for USGS geomagnetic hazard maps.
- Working closely with the NERC Geomagnetic Disturbance Task Force to establish credible standards for assessing the potential impact of a high-impact, low probability geomagnetic disturbance event to power systems.
- Recently published work including: (a) analysis of geoelectric fields induced in the lithosphere during magnetic storms, (b) analysis of periodic geomagnetic variations recorded at observatories (c) outreach articles about induction hazard science.
- Began new scientific research on: (a) analysis of geoelectric fields induced in the Earth's lithosphere during extreme-event magnetic storm impulses, (b) analysis of geoelectric field data collected at the Boulder observatory, (c) development of a lithospheric conductivity model for Florida, (d) analysis of multivariate statistics of ground magnetic disturbance, (e) development of ground magnetic disturbance calculator for geospace model validation.
- National and international coordination activities, including: INTERMAGNET; National Space Weather Program; Geomagnetic Inter-agency Working Group; NERC Geomagnetic Disturbance Task Force; and the American Meteorological Society (AMS) Scientific and Technological Activities Commission for Space Weather.

In 2016, the USGS will provide enhanced monitoring of geomagnetic- and E-field activity at ground level, and establish a national project for mapping time-dependent geomagnetic hazards for assessing national space weather vulnerability and risk:

- Expanded monitoring: Improve magnetic and electrical field monitoring by installing new observatories and variometer stations in the continental United States, adding a Wake Island and South Pole observatory, providing support for the existing Samoan observatory monitoring the crustal electric field at every observatory, and eliminating reliance on transfers from AFWA ($0.5 million).

- E-field monitoring: Begin a national project for detailed geographic and depth-dependent mapping of U.S.-regional lithospheric electrical conductivity, based upon magneto-telluric (MT) methods that exploit known geological structures, the existing USGS magnetic observatory network, and the network expansion proposed above ($0.8 million).
- INTERMAGNET: Work in collaboration with academic and government institutes worldwide to integrate global observatory data with statistical and dynamical models of the magnetosphere and ionosphere to improve regional predictions of hazardous geomagnetic-field activity ($0.2 million).
- Scenario testing: Work in collaboration with electric-power companies, oil and gas drilling industry and the U.S. Air Force to compile information on magnetic-storm effects, and assess geomagnetic hazard vulnerability and risks for technological systems and continuity of operations ($0.2 million).

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Activity: Natural Hazards
Subactivity: Coastal and Marine Geology

2014 Actual: $41.3 million (205 FTE)
2015 Enacted: $40.3 million (204 FTE)
2016 Request: $45.2 million (212 FTE)

Overview

The Coastal and Marine Geology Program (CMGP) applies capabilities in marine geology, geochemistry and oceanography to provide information and research products on conditions and processes critical to the management of the Nation's ocean, coastal and Great Lakes environments. Program activities include characterizing and understanding ocean and coastal geological settings and processes to provide the data and tools for regional and national assessments of coastal and marine conditions, change, and vulnerability. Integrated mapping and research activities support development of data resources, models and decision-support tools to address policy and management issues at national and regional scales.

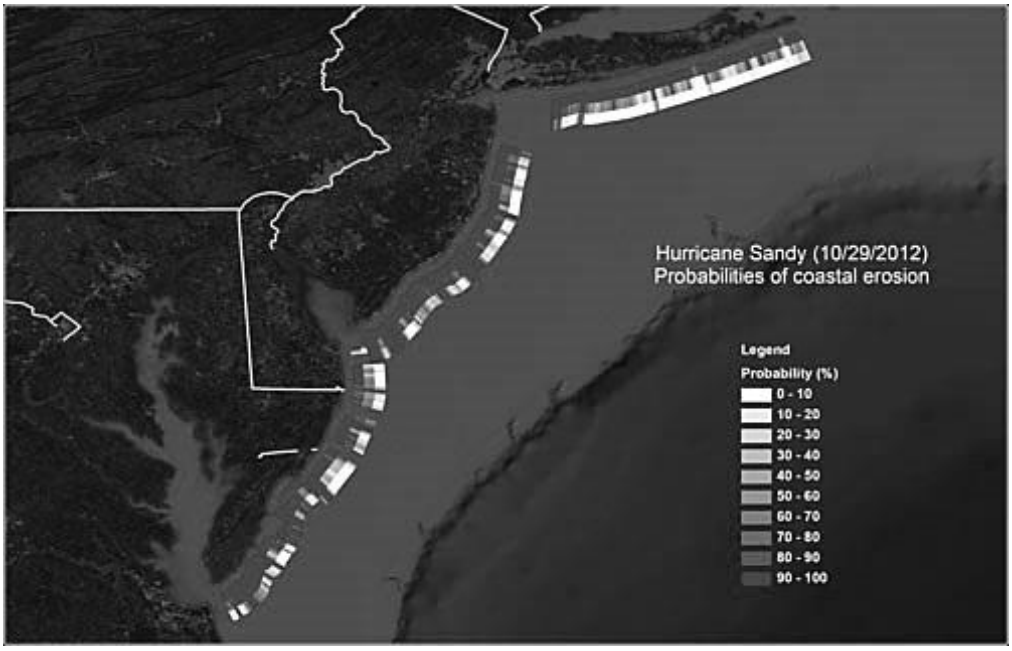
Program Performance

In 2016, ongoing priority studies will address coastal resilience and climate adaptation through regional and national studies of coastal change hazards; cooperative research on marine gas hydrate systems as part of the global carbon system; and delineation of the Extended Continental Shelf, as an expressed policy of the Administration, consistent with the United Nations Convention on the Law of the Sea. Relevant projects additionally include studies of coral reef health to support Ecosystem-Based Management and Climate Adaptation; integrated research to inform regional restoration of coastal estuaries; cooperative mapping, including lidar and seafloor mapping to support State, tribal, and Federal objectives; and improved provision of data, models, and assessments to inform policy and management of coastal and ocean resources. Planning and implementation of this portfolio of activities is the result of cooperative partnerships with other agencies and local stakeholders who expect timely project completion and provision of products.

The CMGP conducts field and interpretive activities to support environmental mapping for management needs within Marine Sanctuaries, National Parks, Fish and Wildlife Refuges, Marine Monuments, and management of fisheries and other living marine resources in State and Federal Waters. In 2016 and beyond, benthic habitat and other seafloor mapping for State and Federal management agencies will only be supported where it enables scientific studies addressing CMGP research priorities and where substantial cost sharing from partnering agencies is available.

Follow-on Research related to Impacts of Hurricane Sandy

The USGS has produced numerous reports, data series, and Web pages providing pre- and post-storm assessments of Hurricane Sandy impacts. Days before Sandy made landfall in southern New Jersey, the USGS Hurricanes and Extreme Storms team developed and issued forecasts on the storm's likely effect on the coastal landscape. The team used NOAA wave height and water level forecasts in combination with a USGS storm-impact model to predict patterns of sediment erosion and deposition (*http://coastal.er.usgs.gov/hurricanes/sandy/coastal-change/*) from the landfalling storm. In addition, a pre-storm Global Positioning System (GPS) ground survey was conducted for Fire Island, NY, an area that experienced substantial coastal change during the storm. Along the severely impacted New Jersey coast pre-storm topographic measurements were made using EAARL-B (Experimental Advanced Airborne Research lidar). These pre-landfall measurements provided crucial baseline information for assessing and understanding the storm's impacts. After the storm, the team acquired imagery from a variety of sources, documenting beach and dune erosion, overwash (occurs when storm waves overtop dunes and carry sand inland), and inundation (complete submersion of beach and dunes). This imagery provided objective observations to "ground-truth," evaluate, and improve USGS pre-storm assessments. Aerial photographs were acquired during a two-day mission flown along the shoreline from the Outer Banks of North Carolina to coastal Massachusetts. Post-storm photographs were compared with those taken before the storm to document coastal change throughout the impact zone. To view examples, visit *http://coastal.er.usgs.gov/hurricanes/sandy/photo-comparisons/*. Many more photo pairs are posted at *http://coastal.er.usgs.gov/hurricanes/sandy/post-storm-photos/obliquephotos.html*.



Hurricane Sandy probabilities of coastal erosion (10/29/12).

Seven projects, funded by emergency Hurricane Sandy disaster relief appropriations, use scientific monitoring, mapping, modeling, and forecasts to support broader recovery efforts throughout the

impacted region. This scientific work assists Interior's efforts to restore Federal lands and facilities and assists States, cities and communities to recover and rebuild in a more resilient manner.

These projects are completing planned activities and products and include—

(1) Coastal Mapping Products and Impact Assessments – will improve digital elevation products for the coastal United States as part of a full-systems project that documents performance of EARRL-B detector, enhances lidar-processing algorithms, and accelerates delivery of digital interpretive products that document coastal change and establish the post-storm vulnerability of coastal communities.

(2) Impacts to, and Vulnerability of, Coastal Beaches – will finish validation and refinements of forecasts of impacts of extreme storms 24 to 96 hours before an extreme storm makes landfall and provide updated forecasts of vulnerability to future storms.

(3) Coastal Hazards Information and Decision Support Portal – will be upgraded in response to user comments to improve delivery of hazards information. Enhancements will improve easy retrieval and use by non-scientists so that data, model outputs, and vulnerability forecasts inform preparation, response and recovery efforts before, during and after storms and other coastal hazards.

(4) Barrier Island and Estuarine Wetland Physical Change Assessment – will aid coastal ecosystem managers in understanding long- and short-term impacts of storms on physical conditions of wetland-dominated ecological habitats.

(5) Fire Island, NY: Linking Coastal Processes and Vulnerability – has completed most complex tasks to improve understanding of sediment supply and exchange between offshore sand features and beach/dune systems along Fire Island. The project will publish final maps, reports on oceanographic observations, and test models developed to forecast long-term barrier evolution and storm response and recovery.

(6) Delmarva Peninsula: Coastal Vulnerability and Resource Assessment – will improve knowledge of the geologic framework and sand transport of a series of Federal and State wildlife reserves to provide regional resource managers with the region's first high-resolution geologic, elevation, and coastal condition maps.

(7) Estuarine Response to Storm Forcing – will measure and model hydrodynamics and sediment transport within Atlantic lagoonal estuaries in order to asses alternative future scenarios that combine natural changes with different management strategies to enhance resilience.

Coastal Lidar Mapping

The 2014 enacted appropriations included an increase of $1,000,000 for coastal mapping using lidar. These funds allowed USGS to partner with the U.S. Army Corps of Engineers (USACE) to produce high-resolution elevation data and maps for a significant portion of Puget Sound. Ongoing CMGP efforts (in support of the 3DEP program and in collaboration with NOAA and the USACE) are developing seamless topographic/bathymetric coastal elevation models based on accurate and up-to-date lidar data. Support will also be provided to improve methods for mapping coastal features, including coastal bluffs and

complex wetland shorelines. These will facilitate application of lidar data to more diverse coastal settings, expanding the value and use of lidar for research and management. During 2015, the USGS will release coastal elevation data for parts of the Gulf of Mexico and the Mid-Atlantic region. Lidar collection in 2016 will proceed in a prioritized manner to expand coastal coverage for the Pacific Northwest, Gulf of Mexico, and Atlantic Southeast coasts.

North Atlantic Cruise – Extended Continental Shelf Characterization

The USGS will conduct a second multi-purpose ocean research cruise in the spring 2015 to perform geophysical surveys to characterize the geologic structure along deep-water portions of the U.S. North Atlantic Margin. This cruise will meet objectives for (1) delineating geologic features that extend the limits of the U.S. Continental Shelf in the North Atlantic, (2) advancing understanding of geologic conditions that could produce submarine landslides resulting in tsunamis, and (3) identifying geochemical conditions associated with methane seeps and changes in carbonate chemistry that drive ocean acidification. The USGS is working with the National Science Foundation to maximize use of Federal oceangoing vessels and to provide opportunities for young/early career scientists. During the 2014 cruise, the USGS field program acquired ~2,760 km of multichannel seismic data during 24 days at sea. The main ECS objective was to collect reconnaissance sediment thickness data along the Atlantic margin to understand the variability in sediment thickness and, in particular, test the hypothesis that sediments are thicker along fracture zones than in areas between fracture zones. An additional objective was to investigate landslide hazards potential for the Cape Fear Slide (CFS) zone. The CFS transect showed the complexity of the slide (multiple headwalls, the possibility of multiple older landslide or mass wasting deposits, and the possibility of complex structural fabrics within these deposits) and suggests the most recent slide is extremely young geologically, but this observation needs additional analysis and possibly additional data to confirm. The importance of this discovery is that the CFS is only slightly smaller in length and width than the largest known modern submarine landslide, namely, the Storegga Slide off Norway.

Model of Residual Oil from Deepwater Horizon

The USGS released a new computer model to track the movement of residual oil that persists along the northern Gulf of Mexico coast four years after the *Deepwater Horizon* disaster released several million barrels of gas and oil into the gulf. This new model helps guide ongoing cleanup efforts and can be used to aid the response to future oil spills. The modeling framework developed for this application responds to the particular requirements of the oil-spill response community by applying USGS modeling, data, and analytical resources developed through prior studies to assess and forecast coastal change as part of a sustained national effort.

Sea Level Rise and Pacific Atolls

USGS scientists conducted fieldwork in the Marshall Islands with collaborators from the National Oceanic and Atmospheric Administration (NOAA) to gather data on bathymetry, topography, tides, waves, run-up, and the resulting wave-driven inundation of the atoll islands. The work is part of a project funded by the Department of Defense (DOD) to assess the impacts of sea-level rise and climate change on

Pacific atolls that house DOD installations. The findings will aid Pacific island nations already threatened by sea-level rise and changing climate.

During the March 2, 2014, overwash in the Republic of the Marshall Islands, seawater regularly topped the manmade perimeter berm on the island of Roi-Namur and covered large areas of the adjacent land surface. Inset shows location of photograph.

San Francisco Bay Long-Term Studies

An intense analysis of the San Francisco Bay Coastal System in California was published in a special volume of the journal *Marine Geology*. The collection of 21 scientific papers features state-of-the-art approaches to understanding physical processes related to sediment transport, geomorphic changes and changing circulation patterns on the complex coastal-estuarine systems. The papers focus on four primary areas: (1) framework geology, (2) sand provenance, (3) circulation patterns and geomorphic change, and (4) fine sediment transport. By understanding the processes at work within the Bay, managers will make better-informed decisions about habitat restoration, erosion control, sediment dredging, and freshwater diversions, especially during periods of weather extremes (long-term drought and intense storms).

Leadership on Coordinated Mapping and Coastal Data Interoperability

Beginning in 2012, the USGS ramped up efforts to provide seafloor characterization and maps to address coastal resources management prioritized requirements in Massachusetts and California State waters. Building on these substantial cooperative-mapping programs, the USGS increased investment for conceptualizing a coastal component of the National Elevation Data as an integral part of the National Geospatial Program's 3DEP initiative. Accurate and up-to-date elevation data across the coastal/marine interface is a foundational requirement for management assessment of habitat and community vulnerability, evaluation of ecosystem protection strategies, and development and protection of offshore resources, including renewable energy sites. The USGS co-authored the draft National Coastal Mapping Strategy (NCMS) in cooperation with NOAA, the U.S. Army Corps of Engineers and various other agencies. The goal of the National Coastal Mapping Strategy is to build upon existing interagency cooperation in coastal mapping to improve coordination on the acquisition, processing, dissemination, archiving, and broad use of airborne lidar elevation and other associated mapping data in the coastal zone.

2014 – Mapping and Data Accomplishments

The USGS launched a Coastal Change Hazards Portal during summer 2014, which allows users to access information online to help understand and anticipate coastal change and vulnerability. The portal is initially populated with published data and vulnerability assessments for extreme storms, long-term coastal change, and sea-level rise. Users can search, view, and share multiple USGS coastal vulnerability products. The site includes a tutorial video to train users on the functionality of the hazards assessment tools. The Portal is included in hazards.data.gov and climate.data.gov.

USGS research oceanographer Richard Signell was awarded the 2014 Russell L. DeSouza Award by the Unidata Users Committee. The DeSouza Award honors "individuals whose energy, expertise, and active involvement enable the Unidata Program to better serve the geosciences." Unidata, funded primarily by the National Science Foundation, is a community of education and research institutions focused on providing data, software tools, and support to enhance Earth-system education and research.

2015 – Mapping and Data planned activities

A USGS scientist introduced NATO scientists to tools, methods, and standards to facilitate NATO adoption of the new U.S. Integrated Ocean Observing System's Web-service based access methods and ensure seamless integration with their existing data. By implementing this new standardized system, NATO scientists were able to search international databases for datasets that met their criteria, extract specific data required for their analysis directly from remote servers, and compare model simulations with field observational data. Outreach with this group provides strong links with an active global community. Training was provided for scientists at NATO's Centre for Maritime Research, who serve in rotating three to five year positions. As they return to their native NATO countries and institutions, they will help spread the adoption and development of this standards-based approach.

In 2015, the USGS will continue to use supplemental funds, resulting from Hurricane Sandy, to upgrade the Coastal Change Hazards portal to include a decision-support functionality that integrates vulnerability

products across three assessment themes: (1) Understanding and Predicting Storm Impacts, (2) Measuring Long-Term Change, and (3) Understanding Vulnerability to Sea Level Rise. The USGS co-chairs the working group on Climate Change and Ocean Acidification, and will work with the Subcommittee for Disaster Reduction (also USGS co-chaired) and the U.S. Global Change Research Program to identify scientific and technological priorities and opportunities. This will improve preparation and response to extreme events, including Federal investments in long-term recovery, and effectively promote resilience to climate change. The USGS will use this interagency effort to prioritize further development of information and tools that support enhanced resilience, adaptation to climate change, and integration of "green infrastructure" into hazard mitigation. For example, to meet ecosystem-based management goals and objectives, an initial focus is on forecasting coastal habitat sustainability (e.g., availability of suitable piping plover nesting locations) in response to coastal change and management strategies.

2016 – Mapping and Data planned activities

The USGS will continue to prioritize application of its world-class seafloor and coastal mapping capabilities to those regions where partnerships effectively leverage resources and enhance the value of the resulting data and products to USGS research objectives and regional partners. Better characterization of the seafloor and its contribution to sediment transport, providing or removing sand to barrier islands and coastal beaches, will be an important component for improving assessments of vulnerabilities of coastal communities—both human and ecological—from impacts of climate change.

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Water Resources

Activity: Water Resources

		2014 Actual	2015 Enacted	2016 Fixed Costs and Related Changes (+/-)*	2016 Internal Transfer	2016 Program Changes	2016 Budget Request	Change from 2015 (+/-)
Water Availability and Use Science Program		38,544	40,919	806	-174	5,207	46,758	5,839
($000)	FTE	300	298	0	-1	5	302	4
Groundwater and Streamflow Information Program		66,069	69,707	798	0	3,028	73,533	3,826
($000)	FTE	384	393	0	0	8	401	8
National Water Quality Program		96,168	94,141	1,788	-2,191	2,349	96,087	1,946
($000)	FTE	747	741	0	-18	8	731	-10
Water Resources Research Act Program ($000)		6,500	6,500	0	0	0	6,500	0
	FTE	2	2	0	0	0	2	0
Total Requirements ($000)		**207,281**	**211,267**	**3,392**	**-2,365**	**10,584**	**222,878**	**11,611**
	Total FTE	**1,433**	**1,434**	**0**	**-19**	**21**	**1,436**	**2**

**Fixed Costs are $2,539 and Seasonal Federal Health Benefits are $853*

Summary of Program Changes

Request Component	($000)	FTE	Page
Water Availability and Use Science Program	**5,207**	**5**	
Critical Landscapes: Arctic	750	2	C-22
WaterSMART: Drought	301	2	C-13
WaterSMART: National Hydrologic Model	750	1	C-11
WaterSMART: Streamflow Information	400	0	C-7
WaterSMART: Water Use Information	3,000	5	C-5
WaterSMART: Water Use Research	1,000	0	C-8
HR&D Monitoring and Assessments	-550	-3	C-15
Model Development and Research	-444	-2	C-15
Groundwater and Streamflow Information Program	**3,028**	**8**	
Natural Hazard Science for Disaster Response: Expand Use of Streamgages	700	4	C-34
Tribes	500	3	C-16
WaterSMART: Groundwater Network	1,000	1	C-9
WaterSMART: Streamflow Information	928	0	C-7
HR&D Monitoring and Assessments	-100	0	C-14
National Water Quality Program	**2,349**	**8**	
Critical Landscapes: Puget Sound	100	1	C-23
Critical Landscapes: Upper Mississippi River	100	1	C-25
Enhanced Cooperative Activities and Urban Waters	717	5	C-52
Support NAWQA Cycle Three	1,881	4	C-14
Unconventional Oil and Gas Research	901	2	C-69
HR&D Monitoring and Assessments	-350	-1	C-15
Water Quality Monitoring	-1,000	-4	C-14
Total Program Change	**10,584**	**21**	

Justification of Program Changes

The 2016 Budget Request for the Water Resources Mission Area is $222,878,000 and 1,436 FTE, a net change of +$11,611,000 and +2 FTE from the 2015 Enacted level. For more information on the Water Resources Mission Area changes, please see Section C, Program Changes as indicated in the table. For more information on the Water Resources Mission Area budget restructure, please see Section B, Technical Adjustments.

Activity Summary

The Water Resources Mission Area is comprised of four subactivities—

- Water Availability and Use Science Program
- Groundwater and Streamflow Information Program
- National Water Quality Program
- Water Resources Research Act Program (WRRA)

Since 1879, the U.S. Geological Survey (USGS) has addressed issues of water availability and quality, drought, and flood hazards. Today, hydrologic professionals and support staff located in all 50 States and Puerto Rico, continue this legacy of providing the Nation with critical water information. As the primary Federal science agency for water information, the USGS monitors and assesses the amount and characteristics of the Nation's freshwater resources, assesses sources and behavior of contaminants in the water environment, and develops tools to improve management and understanding of water resources. Information and tools allow first responders, the public, water managers and planners, and policymakers to—

- Minimize loss of life and property as a result of water-related natural hazards, such as floods, droughts, landslides, and chemical spills.
- Manage freshwater, both above and below the land surface, for domestic, public, agricultural, commercial, industrial, recreational, and ecological uses.
- Protect and enhance water resources for human health, aquatic health, and environmental quality.
- Contribute to wise use, development, and conservation of the Nation's water resources for the benefit of present and future generations.

The Water Resources Mission Area supports the following Interior 2014 – 2018 Strategic Plan goal to "Provide Water and Land Data to Customers." In particular, the Water Resources Mission Area supports the "Monitor and assess water availability and quality" element in the Strategic Plan. The USGS will continue to monitor and conduct research to generate a more precise estimate of water availability and use, and the influence that water quality has upon it, for meeting current and future human, environmental, and wildlife requirements. These research and monitoring activities will help identify water resources for use by humans and the environment while also developing tools to forecast likely outcomes for landscape-level planning needs including water use and quality, and aquatic ecosystem health affected by changes in land use and land cover, natural and engineered infrastructure, water use, and climate.

The *USGS Water Science Strategy: Observing, Understanding, Predicting, and Delivering Water Science to the Nation* (*http://pubs.usgs.gov/circ/1383g/circ1383-G.pdf)* was released in 2013. The Science Strategy provides five high-level goals for the Water Resources Mission Area for the coming decade:

1. Providing society the information it needs regarding the amount and quality of water in all components of the water cycle at high temporal and spatial resolution, nationwide.
2. Advancing our understanding of processes that determine water availability.
3. Predicting changes in the quantity and quality of water resources in response to changing climate, population, and land and water management.
4. Anticipating and responding to water-related emergencies and conflicts.
5. Delivering timely hydrologic data, analyses, and decision-support tools seamlessly across the Nation to support water-resource decisions.

The Strategy outlines areas where USGS hydrologic science can make substantial contributions to the Nation and identifies opportunities for the USGS to better use its capabilities to address Administration priorities to ensure healthy watersheds and sustainable, secure water supplies. In doing so, the Strategy informs long-term approaches to USGS program planning, technology investment, partnership development, and workforce and human capital strategies. The choice of strategic water science priority actions, goals and objectives is based on the guiding principles to *observe, understand, predict* and *deliver* water information that allows society to meet the water challenges of the Nation, current and future. While the Strategy does not cover all facets of USGS work in hydrology, it builds on a hierarchy of planning documents and provides a science-based response to the overarching issues of water availability and hydrologic hazards.

In order to achieve the Strategy vision, it is critical to align funding with the Strategy's goals and objectives. In 2016, the USGS will align the Water Resources Mission Area budget structure to the Water Science Strategy by consolidating its seven existing programs into four. The Groundwater and Streamflow Information Program, primarily focuses on *Observing and Delivering*. The other three programs, National Water Quality Program; Water Availability and Use Science Program; and Water Resources Research Act Program primarily focus on *Understanding, Predicting, and Delivering,* although observations are an essential component of understanding and predicting. A detailed description of these changes to the Water Mission Area Budget Structure can be found in Section B, Technical Adjustments. The Water Resources Research Act Program remains unchanged in the USGS budget structure and serves as an institutional mechanism for promoting State, regional, and national coordination of water resources research, training and information and technology transfer.

The Water Resources Mission Area carries out its programs through the USGS Water Science Centers covering all 50 States and Puerto Rico, as well as its three major research installations located in Reston, VA, Denver, CO, and Menlo Park, CA. The Mission Area encompasses 1,436 scientists, technicians, and support staff and covers all aspects of the hydrologic sciences. In 2014, Mission Area staff published approximately 3,100 publications and supplied monitoring data to its stakeholders through its National Water Information System (*http://waterdata.usgs.gov/nwis*).

During the past year, the Water Resources Mission Area has achieved the following accomplishments, as they would be tied to the four new Mission Area programs:

Water Availability and Use Science Program

- Advancing regional studies of groundwater availability. In 2014, five regional water resource assessments and related data collection took place in the following principal aquifer system:
  - Northern Atlantic Coastal Plain Aquifer System (Long Island, New York to North Carolina)
  - Williston and Powder River Structural Basins (Montana, North Dakota, South Dakota, Wyoming)
  - Hawaiian Volcanic-Rock Aquifers (Hawaii)
  - Ozark Plateaus Aquifer System (Arkansas, Kansas, Missouri, Oklahoma)
  - Glacial Aquifer System (all or parts of 25 Northern States from Maine to Washington and Alaska)
- Advanced the National Brackish Groundwater Assessment, which was authorized in the SECURE Water Act (2009). Groundwater chemistry data from about 400,000 sites were compiled from more than 30 national, regional, and state sources for developing updated maps of the distribution of brackish groundwater.
- Quantified regional groundwater resources in the Powder and Williston Structural Basins.
- Supported a new method to assess the feasibility of forecasting groundwater levels.
- Released a new model and report for estimating consumptive use of cooling water at thermoelectric generating plants.
- Held a major Special Session at the first annual Joint Aquatic Sciences Meeting on Ecological Water Use in May 2014.
- Improved characterization and monitoring of permafrost and hydrology in interior Alaska via airborne geophysical techniques, remote sensing, streamgaging, and ground-based observations, and developed a regional groundwater flow and energy model that encompassed the 11-million acre U.S. Fish and Wildlife Service Yukon Flats National Wildlife Refuge, including over 20,000 wetlands.
- Published and released the USGS water use compilation for 2010, which indicated that 2010 withdrawals were 13 percent less than total estimated withdrawals in 2005, and represented the lowest level of total withdrawals for all uses in the last 45 years.

Groundwater and Streamflow Information Program

- Enhanced the stability of the USGS streamgaging network fully funding 976 streamgages with direct Federal funds, which adds an additional 180 fully funded USGS streamgages relative to 2013.
- Invested funds in new, updated software for the National Water Information System (NWIS) database, which will upgrade the USGS's ability to provide quality and timely streamflow information and to improve efficiency by reducing time required for data management by 20 percent.
- In cooperation with the Water Census instituted a national analysis of surface water records to examine the magnitude, frequency, and duration of drought occurrence in 21 major watersheds and provide a foundation for prediction of future drought occurrence. The effort will be completed in the second quarter of 2015.
- With more than 850 cooperators, supported monitoring at more than 8,000 streamgages and at more than 10,000 wells. Streamgage data are used for a multitude of purposes, including to protect life and property, manage water supplies, and to plan recreational activities; groundwater data are increasingly important for tracking drought and groundwater depletion from overuse.

National Water Quality Program

- Compared pesticide occurrence in the Nation's streams and rivers for periods 1992–2001 and 2002–2011.
- Provided estimates of major sources of nutrients to the Nation's estuaries and Great Lakes.
- Provided an online, interactive SPARROW decision support system for salinity in the Nation's surface waters.
- Developed an interactive, sediment data portal to improve the utility and accessibility of suspended sediment data for watershed managers, policymakers, researchers, and the public.
- Published a synthesis of groundwater quality conditions for some of the largest and most important water-supply aquifers of the United States.
- Conducted water resource investigations with States and localities on effects of urbanization and agriculture on water quantity, contaminants, and ecosystem health in rivers and streams in 32 States.
- Conducted water resource investigations with 92 tribes in 22 States on sustainability of water for drinking water, nutrient enrichment, toxics, habitat, and ecosystem health.
- Conducted water resource investigations on effects of unconventional oil and gas development and other energy development on water quantity and quality in major areas of development across the Nation, including the Bakken, Marcellus, and Fayetteville Shale plays.

Water Resources Research Act Program

- Developed a new public Web site for the WRRA Program that allows searching for grants on science topics, links publications to individual grants, and presents all four parts (annual base grants, competitive grants, coordination grants, and student internship) of the program to the public. (*http://water.usgs.gov/wrri/index.php*).
- With the National Institutes for Water Resources, developed a communications package, explaining the unique Federal-State partnership and the role of the Institutes in the Water Resources Mission Area of the USGS.

Finally, $60,709,000 of the requested funds for the Groundwater and Streamflow Information Program, the National Water Quality Program, and the Water Availability and Use Science Program are recommended for use in matching States, municipalities, and tribes' contributions for cooperative water efforts. In the budget restructure, the Cooperative Water Program has been divided into the Groundwater and Streamflow Information Program, the Water Availability and Use Science Program, and the National Water Quality Program according to its science activities. The matching component of the Cooperative Water Program remains.

Activity: Water Resources
Subactivity: Water Availability and Use Science Program

2014 Actual: $38.5 million (300 FTE)
2015 Enacted: $40.9 million (298 FTE)
2016 Request: $46.8 million (302 FTE)

Overview

The Water Availability and Use Science Program will encompass the Water Resources Mission Area's objectives to provide comprehensive water availability and use science to the Nation. This program also fulfills the goal stated in the SECURE Water Act (P.L. 111-11), Section 9508, to establish a "national water availability and use assessment program." The Water Availability and Use Science Program will synthesize and report information at regional and national scales, with an emphasis on compiling and reporting the information in a way that is useful to States and others responsible for water management and natural resource issues.

Historically, the water availability and use science activities have been managed through multiple USGS programs and technical offices. Beginning in 2016, the information will be integrated under one program to enhance its comprehensiveness and interdisciplinary value and more effectively represent the science components necessary to study this complex area of water resources.

Vital components of the program include most of the components of the WaterSMART Initiative, the regional groundwater availability evaluations, the USGS National Water Use Information activities, the Water Energy Food Nexus work, Environmental flows, drought science activities, and all water availability scientific analyses and research conducted in the Water Resources Mission Area through its current Hydrologic Research and Development and Cooperative Water Programs. This program will also be responsible for the support of information management functions that are vital to the dissemination of water availability and use scientific information.

The goals of the Water Availability and Use Science Program directly support the USGS Science Strategy focus on the Water Census theme, providing scientific information on water availability and quality of the United States to inform the public and decisionmakers about the status of water resources and how they are changing.

Groundwater is among the Nation's most precious and increasingly important natural resources. Groundwater is the primary source of drinking water for approximately 130 million of the Nation's population, provides about 40 percent of the irrigation water necessary for the Nation's agriculture, sustains the flow of most streams and rivers, and helps maintain a variety of aquatic ecosystems. The continued availability of groundwater is essential for current and future populations and the economic health of our Nation. The Water Availability and Use Science Program will provide objective scientific information and interdisciplinary understanding necessary to assess and quantify availability and

sustainability of the Nation's groundwater resources. Results of those efforts provide information used in decisionmaking by resources managers, regulators, other government agencies, and individuals in the public and private sectors. The program will: (1) provide fundamental information about groundwater availability in the Nation's major aquifer systems; (2) characterize natural and human factors that impact recharge, storage, and discharge in the Nation's major aquifer systems, and improve understanding of these processes; (3) develop and test new tools and field methods to analyze groundwater flow systems and their interactions with surface water; and (4) provide scientific leadership across all Federal programs about the Nation's groundwater resources, including research directions, quality control, technology transfer, and information storage and delivery.

The Water Availability and Use Science Program encompasses the majority of funding for the WaterSMART Initiative. The program supports WaterSMART and the Water Census through work to estimate flows at unmonitored locations, water use information aggregation and analysis, and work on ecological water science. This program also funds studies of climate variability and change, watershed-modeling activities and support for the National Research Program in the hydrologic sciences. The Water Availability and Use Science Program supports, maintains, and enhances USGS data delivery systems to process and disseminate study results beyond the immediate needs of funding agencies or programs.

The Water Availability and Use Science Program also supports activities of the Advisory Committee on Water Information, a Presidential Federal Advisory Committee, and its subcommittees. The Advisory Committee on Water Information represents the interests of water-information users and professionals in advising the Federal Government on Federal water-information programs and their effectiveness in meeting the Nation's needs. Member organizations help to foster communications between the Federal and non-Federal sectors on collecting, standardizing, and sharing water information, ultimately resulting in reduced Federal costs for operating resource management and environmental protection programs.

In 2016, the Water Availability and Use Science Program is requesting increases in funding to focus in the Arctic as well as increases associated with the WaterSMART initiative such as streamflow information, drought, national hydrologic model, water use information and water use research. For more information on these requested funding increases, please see Section C, Program Changes.

Program Performance

WaterSMART

(2014 Actual, $7.0 million; 2015 Enacted, $10.0 million; 2016 Request, $15.5 million)

Meeting the water resource needs of the Nation is increasingly challenging in the face of rapidly changing drivers of water availability, such as climate change. At a time when ensuring sustainable water supplies is more important than ever, change in the frequency and magnitude of extreme hydrologic events, such as floods and droughts, is creating levels of uncertainty for water managers. As competition for water resources grows for irrigation of crops, for serving cities and communities, for energy production, and for the environment, the need for information and tools to aid water and natural resource managers grows. WaterSMART is a Department of the Interior (Interior) initiative that leverages and directs existing expertise and resources within the USGS and the Bureau of Reclamation (Reclamation) toward

addressing complex, national- and regional-scale water challenges. The USGS is providing the science to help water managers understand and address competing demands for water. The primary focus of the WaterSMART initiative includes developing a National Water Census, better understanding of water budgets, and supporting sustainable and environmentally sound water management. Leveraging expertise across multiple disciplines enables a broader focus to address these challenging issues in a time of growing competition for water resources. The USGS possesses the skills and foundational resources to provide water resource, ecosystem, and land use managers the decision-support tools to make informed decisions. The goal of the WaterSMART initiative is to improve the data and understanding associated with groundwater, surface water, human water use, and the ways in which they influence water availability, and to develop tools that will allow managers to apply the new understanding and data. The USGS expertise in understanding hydrologic cycle effects on water, human water use, and the ways in which water quality and quantity affect the natural environment is critical to addressing this issue. The Nation will be well served through this effort, by gaining the ability to balance water resource sustainability through consideration of water quantity, quality, and uses, including ecological uses.

In November 2014, the USGS released its most recent compilation of water use, entitled "Estimated Water Use in the United States, 2010." This report provided groundbreaking information on water use trends, showing the largest declines in water use in the last 60 years of records. In 2015, the USGS is providing the first-ever water use grants to State Water Resource Agencies to enhance their ability to provide the base data on water use sectors at the necessary resolution for effective decisionmaking. Comprehensive water use information would be provided on an annual basis for the following sectors of water use: irrigation, public water supplies, thermoelectric cooling water, industrial self-supplied water, and aquaculture. In addition, water use would be estimated for the mining, livestock, and self-supplied domestic water use sectors. The data would be formatted in a manner to allow easy input of water use to the National Hydrologic Model, as well as other models utilized by the USGS. In 2016, the Water Availability and Use Science Program is requesting additional funding to increase water use information. As required under the SECURE Water Act (P.L. 111-11), and the President's Climate Action Plan, the USGS provides comprehensive water use information that will support a host of decision-support systems. This water use information allows resource modelers and managers to understand the influence that human water use has on the hydrologic cycle, the degree to which human consumptive uses influence the sustainability of water supplies, and allows comparison of human water demands to the sustainability of environmental water needs. The USGS has already begun work under the Committee on the Environment, Natural Resources, and Sustainability (CENRS) to coordinate activities with other Federal agencies and State agencies to scope the effort for providing this high-resolution water use information. The USGS is coordinating an effort with the Bureau of Reclamation, the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (USACE), and the Department of Energy (DOE) to improve their ability to feed base data into the water use databases.

In addition, the 2016 requested increase for water use information would allow the USGS to participate in a new multi-agency, Open Water Data Initiative that will integrate water information that is fragmented among multiple bureaus and not readily accessible, into a connected, national water data framework on a geospatial platform. The Open Water Data Initiative will leverage existing partnerships and infrastructure to allow for greater data accessibility and better tools solution development.

In 2014, the USGS furthered it efforts to develop models that will allow uses to estimate daily flow information, at fine scales, for estimates of streamflow in unmonitored location. In 2015, the USGS will complete its evaluation of models necessary for this type of estimation and will develop a plan for implementing streamflow estimation for the coterminous 48 States. In 2016, the Water Availability and Use Science Program is requesting a funding increase for streamflow information, which is required for water-resources management. A goal of the Water Census activity is to provide estimates of streamflow statistics throughout the Nation. The USGS StreamStats decision-support tool allows the USGS and partners to develop these estimates. The StreamStats areal coverage will be expanded by 10 percent, and improved methods for proving the estimates would continue to be investigated.

Finally, the CENRS has recognized the need for a National Hydrologic Modeling Framework to advance understanding and forecasting the water budget, to effectively manage water resources, and to adapt to a changing climate. The USGS currently has a national scale hydrologic model that addresses the major components of the water budget, but human water use is not addressed explicitly. Moreover, information needed to operate the model must be obtained in a somewhat labor-intensive method. As noted by CENRS, there is a need to assemble community modeling resources (i.e., datasets, models, use cases) to economize and enhance model development and verification activities across the community. It assumes continued community use of legacy models and datasets rather than proposing a new model framework. Such an activity would improve and modernize access to resources that support model development, model verification, or model application for a specific decision situation.

In 2016, the Water Availability and Use Science Program is requesting an increase focused on the National Hydrologic Model. The work mentioned above, conducted in collaboration with other Federal agencies with major modeling and data generation activities would accelerate collaborative development of a nationwide hydrologic model that accounts for all aspects of the water budget. Initially, the USGS would work to incorporate remote sensing, including lidar and geophysical data, to refine landscape-scale topography, land cover, geologic framework, soil moisture, evapotranspiration estimates, and changes in depression storage. The USGS would begin steps to improve linkages between surface and groundwater hydrologic models by accommodating variable grid sizes and time steps, nesting existing fine-scale models within coarse-scale regional models. Finally, initial steps would be taken to refine operation of surface water models in sub-daily mode to better forecast flood response in smaller basins.

Drought

(2014 Actual, $0.2 million; 2015 Enacted, $0.2 million; 2016 Request, $0.5 million)

Drought is a present and persistent threat in the Nation. It is often what we think of as the most visible peril to water availability and use and it represents the largest economic impact of all natural disasters, due to its long-term effects and wide spatial extent. In 2014, the USGS engaged in a number of drought activities to help society better understand drought effects on water availability and use and how it manifests in the hydrologic cycle. Further, the USGS is assessing the risk of persistent drought using climate model simulations and paleoclimate data. In the Four Corners region of the Southwest United States, which includes the Navajo nation and Hopi nation reservations, scientists from two USGS science centers in 2015 and continuing in 2016 are using remote sensing and in-situ instrumentation to capture, monitor, and analyze data on the impacts of the continuing drought on the complex and delicate

ecosystems of this region, and its effects on the population of the Southwest. USGS scientists are examining why forest mortality correlates with droughts, investigating the interaction of climate warming, water availability, wildfire stress, and forest health. Forest plots for this study are monitored in Redwood National Park and in the Klamath Range in conjunction with National Park Service partners. In 2015 and 2016, the Water Availability and Use Science Program scientists are also studying land subsidence and groundwater depletion in the San Joaquin Valley to obtain an assessment of drought impacts on subsidence. Finally, the National Water Census, through the Water Availability and Use Science Program, is funding a study to estimate hydrologic drought flow frequency, duration, magnitude, and probability to better understand and anticipate drought streamflow conditions. Two methods of hydrologic drought streamflow probability estimation and hydrologic drought streamflow characterization are tested and evaluated, using criteria appropriate for regions of the United States. This study was ongoing in 2014, and will be completed and the results published in the scientific literature in 2015.

In 2016, the Water Availability and Use Science Program is requesting a funding increase to improve water data and forecasting for drought. The program would create actionable, science-based information and tools as called for under the President's National Drought Resilience Partnership. The NRDP's goal is to make it easier to access Federal drought resources by linking information such as monitoring, forecasts, outlooks, and early warnings with longer-term drought resilience strategies in critical sectors such as agriculture, municipal water systems, energy, recreation, tourism and manufacturing. In addition, the program would enhance research activities to improve drought forecasting. Groundwater and surface water availability changes would be evaluated by improving internal and external coordination and enhancing monitoring activities and data delivery systems to create a stronger link among the ground-based surface water and groundwater monitoring networks of the USGS, groundwater networks of State agencies and the soil moisture network of Natural Resource Conservation Service .

Water-Energy-Food Nexus

The Water-Energy-Food Nexus emphasizes the intricate linkage and interdependency of three sectors of resource management from a sustainability and security perspective—energy, water, and food. As a society, we rely implicitly on all three resources and have come to realize that all three are interrelated and must be managed together. In 2014, the USGS worked to quantify regional groundwater resources in the Powder and Williston Structural Basins. These basins are critical resources for fossil fuel energy development in the continental United States and water resources for gas and oil extraction are a key issue. Two interim reports were published for the Williston and Powder River Basin Groundwater Availability Assessment located in the Bakken formation. The first is "Hydrogeologic Framework of the Uppermost Principal Aquifer Systems in the Williston and Powder River structural basins, United States and Canada" (*http://dx.doi.org/10.3133/sir20145047*). The second, "Conceptual Model of the Uppermost Principal Aquifer Systems in the Williston and Powder River Structural Basins, United States and Canada" (*http://dx.doi.org/10.3133/sir20145055*) documents a model of the uppermost principal aquifers in this area. These aquifers contain a major part of the Nation's reserves of coal and natural gas and are a water-supply alternative for some of the Nation's most rapidly developing oil reserves in the Bakken formation play.

In 2014, the USGS also initiated a request for proposals to study unconventional oil and gas (UOG) exploration water use practices. The Bakken structural formation was selected as the site to the pilot study to be conducted. In 2015, USGS scientists are working with stakeholders in the Bakken formation to develop a plan of study for the UOG water use effort. The main part of the project will be started in 2016, and will proceed for three to four years, at which time the techniques learned in the Bakken pilot effort will be extended to other UOG water use in other parts of the Nation.

Water Use

(2014 Actual, $1.8 million; 2015 Enacted, $4.3 million; 2016 Request, $8.3 million)

Water use is an integral part of the hydrologic cycle. It provides an understanding of the influence that humans have when they withdraw water, move it from one part of the landscape to another, consumptively use water or return the water back to the environment through wastewater discharge, irrigation, or other means. In 2014, two new reports were issued for estimating consumptive use of cooling water at thermoelectric generating plants in the United States. The first report, "Methods for Estimating Water Consumption for Thermoelectric Power Plants in the United States" (*http://pubs.usgs.gov/sir/2013/5188/*), documents the model. The second report, "Withdrawal and Consumption of Water by Thermoelectric Power Plants in the United States, 2010" (*http://pubs.usgs.gov/sir/2014/5184/*), provides a plant-by-plant comparison of all 1,300 facilities in the United States.

Also in 2014, the USGS released a water use compilation for 2010, entitled, "Estimated Use of Water in the United States in 2010" (*http://pubs.usgs.gov/circ/1405/*). This report was groundbreaking in that it documented significant declines in water use in the last five years. Total estimated withdrawals in 2010 in the United States were 355 billion gallons per day, or 13 percent less than total estimated withdrawals in 2005. This represented the lowest level of total withdrawals for all uses in the last 45 years.

Plans for water use projects in 2015 include the USGS continuing to develop a site-specific water use database for the 57,000 public water supply systems in the Nation. This involves obtaining the monthly and annual water withdrawals for the over 7,000 surface water intakes and over 100,000 public supply wells in the Nation.

In 2016, the USGS plans to begin work on the 2015 Water Use Compilation for the Nation. The Water Use Compilation is an ongoing effort to inventory all of the water use in the Nation and results in a Circular report, entitled "Estimated Use of Water in the United States, 2015." Compilations of water use have been published by the USGS every five years since 1950, and represent one of the most widely cited products of the USGS.

Groundwater Resources Studies

(2014 Actual, $3.6 million; 2015 Enacted, $3.6 million; 2016 Request, $3.6 million)

The USGS is conducting the National Brackish Groundwater Assessment, which was authorized by passage of the SECURE Water Act (P.L. 111-11). Section 9507c of the Act states that the "Secretary of the Interior, in consultation with State and local-water-resource agencies, shall conduct a study of

available data and other relevant information to identify significant brackish groundwater resources in the United States." Groundwater chemistry data from about 400,000 sites have been compiled from over 30 national, regional, and State sources for developing updated maps of the distribution of brackish groundwater.

In 2014, regional studies of groundwater availability are being conducted to quantify current aquifer resources, evaluate how those resources have changed over time, and provide tools to forecast how much water will be available in the future. Five regional water resource assessments and related data collection took place in the following principal aquifer system:

- Northern Atlantic Coastal Plain Aquifer System (Long Island, New York to North Carolina)
- Williston and Powder River Structural Basis (Montana, North Dakota, South Dakota, and Wyoming)
- Hawaiian Volcanic-Rock Aquifers (Hawaii)
- Ozark Plateaus Aquifer System (Arkansas, Kansas, Missouri, and Oklahoma)
- Glacial Aquifer System (all or parts of 25 northern States from Maine to Washington to Alaska)

Finally, in 2014, the USGS supported a new method to assess the feasibility of forecasting groundwater levels. Groundwater responses to climate-related variability are complex because of varying climatic and hydrogeologic settings and varying time lags between aquifer recharge, storage, and discharge. It would be very useful for water managers to have the ability to estimate the probability of occurrence of specific threshold groundwater conditions based on measures of current or recent conditions. The thresholds will be used for identifying events related to selected drought conditions. The development of this new method will is continuing in 2015.

In 2015, the results from the refined and updated Central Valley Hydrologic Model tool will be released providing an analysis of the effects of recent drought conditions in the Central Valley of California on aquifer storage, surface-water/groundwater interactions, and land subsidence. The Bureau of Reclamation along with the California Department of Water Resources use the Central Valley Hydrologic Model tool and information developed as part of the regional groundwater assessments to better understand how water moves through the aquifer system, predict water-supply scenarios, analyze subsidence, and address issues related to water competition in California.

Also, the Floridan Aquifer System Groundwater Availability Study is focusing on the construction, testing, and calibration of the regional groundwater flow model. The objectives of the model are to quantify water availability in the Floridan aquifer system and its sensitivity to varying meteorological and water-use conditions.

In 2016, several of studies mentioned are scheduled for completion, which means steps will also be taken to begin the selection process for water availability studies of new principal aquifers. All these regional assessments are part of an effort to evaluate about 40 regional aquifers across the Nation and when added together will collectively lead to a national assessment of groundwater availability.

Ecological Flows

(2014 Actual, $0.5 million; 2015 Enacted, $0.5 million; 2016 Request, $0.5 million)

The USGS in collaboration with Reclamation organized a Special Session on environmental flow (Eflow) science (the science of flow variability and the related response of the ecological community) at the first ever Joint Aquatic Science Meeting, held in May 2014 in Portland, OR. The Special Session was titled "Environmental Flow Science in the WaterSMART Program." This session was an ideal venue to get the word out to the broader scientific community on all the excellent Eflow science occurring within Interior as part of the WaterSMART Initiative. This Special Session was especially timely given the fact that Eflow science was emphasized as one of the major crosscutting issues among many of the recently released Strategic Plans including Climate and Land Use Change, Ecosystems, Water, and Environmental Health mission areas.

In 2015, efforts to develop a Web tool that integrates the previously published National streamflow classification structure into the National Water Census Data Portal will take center stage. This tool will allow stakeholders to classify streams into hydroecologically relevant stream types and compare local classifications to those of the USGS. Ongoing collaborations with the Southeast Department of the Interior Climate Science Center will result in two timely products in 2015—one comparing the utility of streamflow models in the Southeastern United States for ecological flows and water availability, and a second that links predicted changes in streamflow to fish species richness. The development and Web distribution of a statistical package that calculates a suite of ecologically relevant streamflow attributes via open source statistical software will continue to be a priority.

Broadening the transferability of existing decision-support tools to better understand future water needs will be one of the primary Eflow goals in 2016. Recent droughts in the United States have highlighted limits on the amount of water available to support human and ecological needs and have emphasized the growing gap between water supply and demand. Therefore, adapting existing ecological flow decision support systems to other U.S. river basins to help water managers and stakeholders understand the risks associated with meeting water supply and ecological needs is an essential component of the Eflows toolbox. Additionally, three new Focus Area Studies will be initiated in 2016 including the Coastal Region of North and South Carolina, Red River Basin (Oklahoma, Arkansas, Texas), and the Rio Grande Basin and all will have an Eflow component that will leverage information and tools from prior Focus Area Studies to enhance society's understanding of how changes in water use and availability influence ecological assemblages.

Research

(2014 Actual, $5.0 million; 2015 Enacted, $4.8 million; 2016 Request, $5.7 million)

The Water Availability and Use Science Program promotes the development and application of new methods, models, tools, and decision support systems which allows the USGS to remain in the forefront of water availability and use science. Funds are used for development and technical oversight of this development work to assure consistency and technical excellence. Specific support is provided for models that allow the user to estimate components of the water budget in locations where direct

measurements are not available or for time periods when measurements were not taken. The outcome is a consistent set of water budget information across the Nation.

The exchange of groundwater and surface water is a key element in understanding water availability, both for human uses and for maintaining flows to sustain key aquatic species. The USGS is making important contributions to understanding and documenting the magnitude and impacts of this exchange, as exemplified in some recent activities. In 2014, the USGS, in partnership with numerous State, regional, and local agencies, conducted research to identify causes recent water level declines in White Bear Lake, MN. Recent urban expansion and increased pumping from the Prairie du Chien-Jordan aquifer raised the question of whether a decline in precipitation is the primary cause for the recent water level decline in White Bear Lake. USGS research demonstrated that recent declines in White Bear Lake reflect the declining water levels in the Prairie du Chien-Jordan aquifer. Results from this work are being used to manage water availability for both water supply (aquifer pumping) and recreation (lake levels) and are indicative of USGS contributions to understanding both natural and human influences on availability.

In 2015, the USGS is building on work begun in 2014 to understand the influence of groundwater and surface water on prairie potholes, which are an important habitat throughout the much of the north-central United States. This understanding is particularly relevant in light of recently proposed regulations for surface waters of the United States. USGS researchers are using a combination of hydrologic modeling and tracer studies to determine the connectivity of these landscape features to surface water and groundwater. The work will be extended in 2016 using hydrologic models to simulate changes under changing climate and land management.

Cooperative Water Program

(2014 Actual, $11.0 million; 2015 Enacted, $11.4 million; 2016 Request, $12.5 million)

The USGS conducts approximately 600 interpretative jointly planned and jointly funded studies each year with localities, States, and tribes. Many of these efforts continue foundational and often long-term assessments and research on water availability issues in every State. Development of statistical models and other research tools help to assess conditions over local to regional areas and to allow forecasting into the future. These cooperative efforts help to determine water use, environmental flows, water budgets, streamflow estimates at ungaged sites (during high and low conditions), and groundwater/surface water relations needed to help stakeholders manage vulnerable water supplies, human uses of water, energy, and ecosystems.

Examples are many and address a myriad of water availability issues (*http://water.usgs.gov/coop/products/availability/index.html*). For example, in cooperation with the Middle Pecos Groundwater Conservation District, Pecos County, City of Fort Stockton, Brewster County, and Pecos County Water Control and Improvement District No. 1, the USGS developed a groundwater-flow model of the Edwards-Trinity and related aquifers in parts of western Texas in 2014. This model is a vital groundwater resource for agricultural, industrial, and public supply uses. Scenario testing indicated that increased pumping during the next 30 years might cause groundwater levels to decrease by as a much as 32 feet in parts of the Edwards-Trinity Aquifer (*http://www.usgs.gov/newsroom/article.asp?ID=3810#.U5YThnJdVg0* ; report:

http://pubs.usgs.gov/sir/2013/5228/). The USGS, in cooperation with Miami-Dade County, depicted saltwater intrusion in the Biscayne aquifer to help water managers protect the primary drinking water source for the county's roughly 2.5 million residents. The study, Origins and Delineation of Saltwater Intrusion in the Biscayne Aquifer and Changes in the Distribution of Saltwater in Miami-Dade County, Florida *(http://pubs.er.usgs.gov/publication/sir20145025)*, which used information gathered through 2011, found that saltwater had intruded about 460 square miles of the mainland part of the county (*http://www.usgs.gov/newsroom/article.asp?ID=3898#.U5YLBnJdVg1*).

Also in 2014, in cooperation with the Virginia Department of Environmental Quality, the USGS quantified the components of the hydrologic cycle across the Commonwealth of Virginia. Long-term, mean fluxes were calculated for precipitation, surface runoff, infiltration, total evapotranspiration, riparian evapotranspiration, recharge, base flow (or groundwater discharge) and net total outflow. Final results for the study are presented as component flux estimates for all counties and independent cities in Virginia and can be used for planning and management of water resources in the face of droughts, changing land use and best management practices, and other varying conditions. (Full report: *http://pubs.er.usgs.gov/publication/sir20115198*; technical announcement: *http://www.usgs.gov/newsroom/article.asp?ID=3461*)

In 2016, assessments and research on water availability with localities, States, and tribes will remain a high priority of the USGS. Additional focus will be placed on estimating streamflow at ungaged sites for more accurate water budgets; tracking public supply and other water use information; tracking long-term patterns in groundwater and surface water flow; modeling environmental flows for sustained ecosystems; and advancing evapotranspiration measurements and assessment techniques.

Information Delivery

(2014 Actual, $3.2 million; 2015 Enacted, $3.6 million; 2016 Request, $3.6 million)

The Water Availability and Use Science Program supports the development, implementation, and maintenance of systems for information delivery to all stakeholders that include data processing, quality assurance, storage, and ready available access. The funds ensure the operation and maintenance of the National Water Information System (NWIS) database, which delivers the information vital to the understanding of water availability and use. The USGS Water Data for the Nation Web site (*http://water.usgs.gov/data/*) provides access to the NWIS and information about streamflow, water use, drought, and groundwater levels. In 2014, the USGS provided the first posting of county aggregated water use information via NWIS Web (*http://waterdata.usgs.gov/nwis/wu*). This provided users with more direct access to country and State aggregated data used by the USGS in water use compilations. In 2015 and 2016, Water Availability and Use Science Program's information management scientists will advance the National Water Census Data Portal (*http://cida.usgs.gov/nwc/*) to serve new information to the public, including a Web tool that integrates the National streamflow classification structure and the development and Web distribution of a statistical package that calculates a suite of ecologically relevant streamflow attributes.

In addition, the Water Availability and Use Science Program funds help to produce Web portals with increased access to nationwide and interdisciplinary USGS information (such as demonstrated at the

National Water Census Data Portal - http://cida.usgs.gov/nwc). USGS Water Watch pages remain one of our most heavily used products, reporting real time and summarizing current conditions for groundwater levels (*http://groundwaterwatch.usgs.gov/*)and streamflow (*http://waterwatch.usgs.gov/*).

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Activity: Water Resources
Subactivity: Groundwater and Streamflow Information Program

2014 Actual: $66.1 million (384 FTE)
2015 Enacted: $69.7 million (393 FTE)
2016 Request: $73.5 million (401 FTE)

Overview

Monitoring networks that generate hydrologic data are the foundation of understanding the Nation's water resources. The Groundwater and Streamflow Information Program encompasses the Water Resources Mission Area's objectives to collect, manage, and disseminate consistently high-quality and reliable hydrologic information in real time and over the long term, which are both critical for managing our Nation's water resources and anticipating and responding to water hazards that can result in loss of life and property.

The Groundwater and Streamflow Information Program serves as the national source of impartial, timely, rigorous, and relevant data for short- and long-term water decisions by local, State, regional, and national stakeholders. Decisions based on continuous real-time water data are needed for (but not limited to) emergency response, flood forecasting, reservoir releases, water use restrictions, drinking water deliveries, permit compliance, and recreational safety. Decisions based on long-term data are needed for water-supply planning; aquifer storage and recovery; reservoir, dam, bridge, and transportation infrastructure design; floodplain and ecosystem management; energy development; resolution of interstate and international water disputes; and forecasting changing water conditions due to land use and climate changes. Access to water information is increasingly more critical as our climate and land use changes and our populations grow, driving an even higher need to sustain water for competing water priorities.

Historically, the collection and dissemination of hydrologic information have been managed through multiple USGS programs, including in large part, the Cooperative Water Program (CWP) and the National Streamflow Information Program (NSIP). Beginning in 2016, the information will be managed and funded in the Groundwater and Streamflow Information Program to enhance its comprehensiveness and interdisciplinary value and more effectively represent key components of the hydrologic cycle (including surface water, groundwater, evapotranspiration, and precipitation).

Vital components of the Groundwater and Streamflow Information program include—

- A unified national streamgaging network of about 8,130 real-time streamgages
- A growing network of interdisciplinary "Super Gages"
- Groundwater level networks, including the collaborative National Groundwater Monitoring Network (NGWMN)

- Development and application of hazard information and tools to minimize loss of life and property
- Research, development, and application of innovative techniques and technical oversight for cost-effective monitoring
- Management and development of instrumentation through the Hydrologic Instrumentation Facility and Branch of Geophysics
- Information management and delivery of hydrologic data

For 2016, the Groundwater and Streamflow Information Program is requesting increases in funding to focus on streamflow information and groundwater monitoring requirements in the SECURE Water Act (P.L. 111-11), the expanded use of streamgages in the Improving Disaster Response initiative, and to strengthen technical information needed to support water rights settlement work. For more information on these requested funding increases, please see Section C, Program Changes.

Program Performance

National Streamflow Network

(2014 Actual, $51.0 million; 2015 Enacted, $52.2 million; 2016 Request, $55.5 million)

In 2014, the USGS streamgaging network provided streamflow information at about 8,130 streamgages (nearly 100 percent of which deliver information in real time). The network is vital for the protection of life and property; national, State, tribal, and local economic well-being; and efficient and effective water resource management. The network was supported collaboratively by the USGS in concert with about 850 Federal, State, tribal, and local agencies and private entities, totaling about $160 million. In 2014, the National Streamflow Network was funded by USGS appropriations (about 17 percent through the CWP and 14 percent through the NSIP); reimbursable funding from local, State, and tribal Cooperators through jointly funded agreements (about 53 percent); and reimbursable funding from other Federal agencies (about 16 percent). This is seen in the Figure 1 below. The breadth of partnerships reflects widespread recognition and support by USGS stakeholders on the agency's critical role and primary responsibility for collecting, analyzing, managing, and delivering streamflow information.

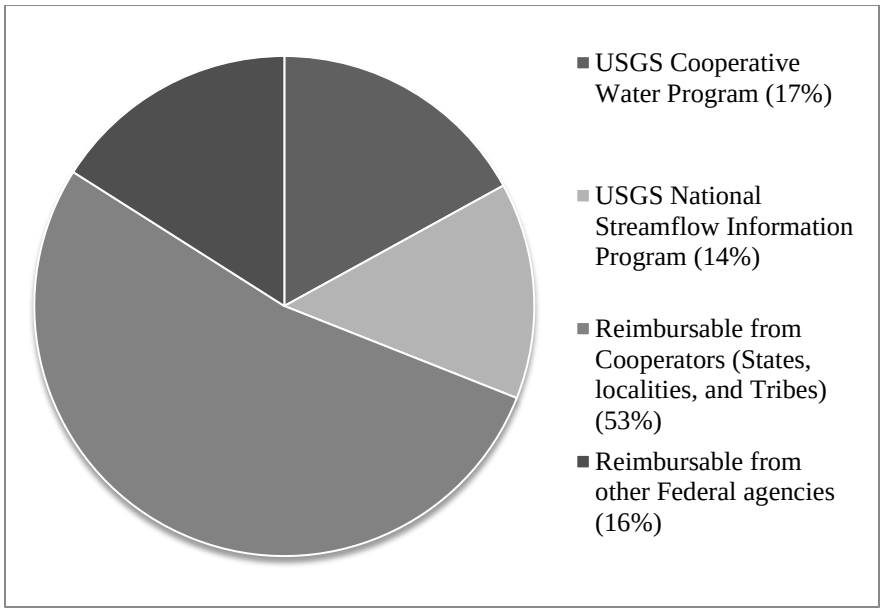

Figure 1 National Streamflow Network Funding

One of the highest priority goals for the National Streamflow Network is to maintain and expand the long-term stability of the National Streamflow Network in recognition that consistent, systematically-collected information is paramount to meet the full gamut of Federal water needs over the long term related to:

- Forecasting extreme hydrologic events (floods and droughts).
- Monitoring water flows across international, interstate, and tribal borders needed to address inter-jurisdictional and court adjudicated water rights and other legal responsibilities.
- Tracking streamflows, water quality, and habitat in major river basins, such as those discharging into key estuaries or draining heavily populated areas.
- Tracking long-term streamflow trends and causes, such as relating to population growth and changes in land use, water use, and climate.

In 2015, approximately 3,100 of USGS streamgages in the current National Streamflow Network are identified as meeting these strategic long-term Federal needs. In 2014, these high-priority streamgages were funded by the NSIP, the CWP, and USGS partners; 976 of these streamgages were fully funded by the USGS (through NSIP), increasing the number of USGS fully funded streamgages by 182 relative to 2013. The increase was due, in large part, to a funding increase to NSIP in 2014 that supported the expansion and improved stabilization of streamgages. Specifically, the 2014 funding increase was applied to high-priority streamgages that were (1) supported by other funding sources which may be less stable over the long term or (2) that were discontinued because of funding reductions in recent years. The increase of $1.2 million to NSIP in 2015 will build upon this investment and continue the expansion and improved stabilization of high priority streamgages.

The remaining 5,000 streamgages in the National Streamflow Network are integral to the unified USGS national streamgaging network because they address the USGS mission and national water priorities

related to hazard mitigation and water availability for human and ecosystem health. In 2014, these 5,000 streamgages were supported by the CWP, in concert with CWP cooperators and other USGS partners. The streamflow information is used to facilitate management decisions, operations, and responsibilities by localities, States, tribes, and other Federal agencies related to, for example, reservoir operation, allocation of safe drinking water, and management of groundwater pumping. In addition, these streamgages provide robustness needed in a national network to cover the broad range of watersheds, hydrologic conditions and water issues across the Nation. Maintaining the full-unified network is vital to support estimates of streamflow at ungaged locations and minimize streamflow information gaps.

The national 8,000-streamgage network is critical during extreme events for hazard response; the majority is used for flood forecasting by the National Weather Service. For example, in Kansas alone the USGS monitored flood conditions at more than 180 streamgages in 2014. Many other peak flooding events were recorded in 2014, including those in August and September in the Southwest following the remnants of Hurricane Odile. The USGS measured the highest discharge measured near Palominas, AZ, which was about 18,000 cubic feet per second with the flood peak being over 16-feet deep. Information was immediately released in timely flood alerts throughout the year.

"The new flood technology on USGS streamgages on Iowa's rivers will help prepare people for dangerous situations like the flash floods of 2010 in East Des Moines. In a lot of cases, minutes mean lives. And that's exactly what this provides us. It's a higher resolution look at the amount of water entering our stream systems." (AJ Mumm, Polk County, Iowa, Emergency Manager)

At the opposite end of the hydrologic spectrum, 2014 brought many drought woes across the Nation. Information from over 4,000 long-record streamgages was used by the USGS and partners to determine the extent, duration, and severity of droughts and to allocate water for critical uses. Streamflow remained well below normal across much of California and eastern Texas. USGS scientists made the needed extra streamflow and groundwater level measurements so that USGS partners had (and continue to have) data to plan for water supplies. Information was immediately released in timely drought alerts throughout the year.

In 2015, the USGS will continue to work with local, State, tribal, and other Federal partners to minimize streamflow information gaps by adding streamgages in unmonitored watersheds and by collecting needed ancillary watershed information to better estimate streamflow at ungaged locations. This information is critical for hazard response and to serve the many uses of streamflow information by the USGS and its partners. For example, other Federal agencies rely on streamflow information to meet their respective obligations: examples include the NWS for predicting floods, the Federal Emergency Management Agency for identifying flood prone areas, the U.S. Army Corps of Engineers for operation of locks and dams, the Bureau of Reclamation for dam and water conveyance systems operations, and the National Park Service (NPS) and Fish and Wildlife Service for managing water resources and ecosystems. For example, the USGS and the NPS jointly operated more than 600 streamgages in 2014 within or near national parks. In

"USGS streamflow information is required to manage our National Parks and assure public safety and property protection, support threatened and endangered species, and accurately assess long-term changes in relatively pristine watersheds resulting from climate change." (Ed Harvey, Director of the National Park Service Water Resources Division)

some places, for example, at Happy Isles along the Merced River in Yosemite National Park, the USGS and NPS have partnered for more than 95 years to measure streamflow.

Local, State, and tribal organizations depend on streamflow information to manage water supply operations (drinking water, irrigation, energy, and reservoirs), waste assimilation, permits, infrastructure, floods, and healthy ecosystems. These organizations are often charged with developing operating strategies to maintain the ecological function of rivers while also serving multiple water needs for recreation, cities, farms, energy production, navigation, and industries. With such diverse requirements, streamgage measurements are fundamental to (1) manage reservoir releases for water supply, irrigation, hydropower, environmental and navigation uses; (2) protect stream ecology and other instream uses; and (3) plan for a sustainable water future.

"USGS streamgage measurements are the single most important sound science tool in the State/Regional/Federal toolbox to leverage the talent and resources of multiple jurisdictions in common ground strategies to assure community flood resilience and long-term water supply needs." (Bob Tudor, with the Delaware River Basin Commission)

Streamflow monitoring is also critical to many tribes in the United States, not only for its importance in flood warning predictions and water supply management, but for tribal sustenance and sovereignty as well.

"*Our Tribe relies on USGS streamflow gaging activities to maintain aquatic habitat and the seasonal harvesting of a variety of native medicinal flora of importance to our tribal lifestyle and long-standing tribal ceremonies. In addition, USGS stream gages, such as on the Meduxnekeag River in Eastern Maine, provide us valuable real-time information on river flow and water-quality that is critical to native fish habitat, including for spawning Atlantic Salmon, a native species the Tribe hopes to restore back to its once healthy populations*." (Ms. Sharri Venno, Environmental Planner with the Houlton Band Maliseet Indians in Houlton Maine)

The general public depends on the information for recreation and safety. The USGS continues to expand uses of streamflow information with the recreational community, including with outfitters and other non-governmental organizations, which need streamflow information on a real-time basis for operations and management of natural resources.

In 2016, a requested increase would support the continued expansion and stabilization of streamgages and information over the full range of hydrologic conditions. In addition, the increase would provide statistical estimates of streamflow at ungaged sites where it is not feasible or practical to place a streamgage, and specifically, test the potential of estimating streamflow in the Alaska frontier using remote sensing. Increased funding would also support flood hardening and infrastructure enhancements at critical streamgages; expanded use of streamgages for hazard response ; for increased capabilities in calculating uncertainty in streamflow (particularly during extreme hydrologic events) at gaged and ungaged locations; and for continued expansion of streamgage uses with the recreation community.

Super Gages to Observe Other Hydrologic Components

(2014 Actual, $0.2 million; 2015 Enacted, $0.4 million; 2016 Request, $1.0 million)

The USGS continues to expand the existing streamgage infrastructure to install "Super Gages" that integrate many types of monitoring sensors that record and transmit hydrologic data at key monitoring locations. Examples of the type of hydrologic data transmitted include meteorological data (precipitation

and evapotranspiration) and physical data such as water temperature and water velocity through optical or hydroacoustic technology. The physical infrastructure of a streamgage and the data recording and telemetry instrumentation it contains makes the streamgage an ideal platform for measuring and transmitting a variety of parameters simultaneously in real time and over the long term, which helps to manage water resources during floods and droughts and over long periods due to changes in water use, land use, and climate. Two examples of recent Super Gages include the Illinois River at Florence, IL (*USGS streamgage 05586300*), which drains urban land, and the White River at Hazleton, IN (*USGS streamgage 03374100*), which drains more than 11,000 square miles of primarily agricultural land. Parameters collected at these Super Gages include water level (stage), streamflow, water velocity, water temperature, nutrients, and suspended sediment. Information from the Super Gages is used to assess short-term, seasonal, and long-term trends in impacts of agricultural, urban, and other land-use practices.

In 2015 and 2016, the USGS will continue to leverage the existing streamgage infrastructure and expand the Super Gage network, where possible, in collaboration with local, State, tribal, and Federal partners.

Groundwater Network and the National Groundwater Monitoring Network
(2014 Actual, $7.0 million; 2015 Enacted, $8.0 million; 2016 Request, $11.0 million)

The quantity of groundwater in an aquifer is an important factor in determining water availability. In 2014, water levels were monitored in about 25,000 wells; groundwater levels were measured in real time in about 1,500 wells; and the response of groundwater levels to changes in climate was measured in about 600 wells. In 2015, the USGS will continue to work with local, State, tribal, and other Federal partners to minimize groundwater information gaps in the Nation's principal aquifers used for drinking, irrigation, energy, and other water uses, and to continue to track effects of climate and drought on groundwater levels over the long term.

The USGS has worked with the state of Pennsylvania for more than a decade to develop a real-time system routinely used in State drought management applications. The tool is instrumental in continuously tracking precipitation, surface water, groundwater, and soil moisture, and highlighting the resource most affected at any given time.

In 2014, groundwater levels in about 9,000 wells located throughout the High Plains aquifer were reported (*http://pubs.usgs.gov/sir/2014/5218/*), with the majority of wells showing declines. This *report* also documented water-level changes and changes in storage from pre-development to 2013. Groundwater levels will continue to be measured throughout the High Plains in 2015 and 2016; a report will be released on changes in water levels since 2014. High Plains water-level monitoring (*http://ne.water.usgs.gov/ogw/hpwlms/*) is the USGS's response to a Congressional mandate to report on water-level changes in the High Plains [Ogallala] aquifer every two years. (The directive from Congress was contained in the Water Resources Development Act of 1986 [Public Law 99-662]). This law recognized the economic importance of the High Plains aquifer to the States in the High Plains region and added Title III to the Water Resources Research Act of 1984 (Public Law 98-242). Title III states that the USGS in cooperation with "...the States of the High Plains region is authorized and directed to monitor the levels of the Ogallala [High Plains] Aquifer, and report annually to Congress." The original directive was modified by the Federal Reports Elimination and Sunset Act of 1995 (Public Law 104-66). In this legislation, Congress directed the USGS to report on water-level changes in the Ogallala [High Plains] aquifer every two years instead of annually.

In 2014, planning and development of the NGWMN design continued, as proposed in 2009 by the Advisory Council of Water Information in response to the SECURE Water Act (P.L. 111-11), which authorized a collaborative groundwater network among Federal, tribal, State, and local agency data providers. In 2015, the NGWMN will use an increase in funding to (1) implement groundwater pilots in Utah and New England; (2) develop a NGWMN information system (or portal, *http://cida.usgs.gov/ngwmn/*) that will provide readily available groundwater information for the Nation's major aquifers to the public; and (3) evaluate and incorporate wells and water-level records across the Nation that meet design criteria (including criteria related to quality, accessibility, and frequency of measurements, goals of the three sub-networks (*http://cida.usgs.gov/ngwmn/learnmore.jsp*), and plans for the USGS Climate Response Network for tracking groundwater levels over the long term).

In 2016, a requested funding increase would enhance groundwater monitoring in principal aquifers heavily used for water supply, irrigation, energy, and other uses in order to develop a more nationally consistent federally funded backbone of groundwater monitoring stations. The NGWMN would be supplemented by increased funds to enhance the USGS Climate Response Network of wells used to track groundwater levels over the long term and to support the incorporation of other qualified water-level monitoring wells and records collected and furnished by the USGS, local, State, or other Federal agencies as part of the NGWMN design.

Water Hazards

(2014 Actual, $2.0 million; 2015 Enacted, $2.0 million; 2016 Request, $3.0 million)

The Groundwater and Streamflow Information Program promotes the development and application of information and tools to minimize the loss of life and property due to hazards, including, for example, support for flood forecast mapping, storm surge monitoring during hurricanes and floods (through rapidly deployable streamgages), drought, debris flows, and fires.

The USGS, in concert with the National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers, and local and State agencies, continue to enhance standardized geospatial flood inundation models and maps indexed to real-time streamgages that show floodwater extent and depth on the land surface. These flood forecasting tools are used for flood response and mitigation and enable emergency management officials at local, State, tribal, and Federal levels to assess flood threats and to see, along with the general public, on a street-by-street basis, the expected extent of a flood hours, or even days, before it occurs. In 2014, flood inundation maps (*http://water.usgs.gov/osw/flood_inundation/studies.html*) were made available for a total of 16 States. For example, maps are now available for Findlay, Killbuck, and Ottawa, OH, for communities along the West Branch Delaware watershed in New York, and watersheds near Atlanta, GA. In 2015, the Groundwater and Streamflow Information Program will continue to develop flood inundation map libraries on the Internet that link USGS streamgages and National Weather Service flood-forecast points and provide flood extent and depth maps for predetermined stream stage intervals.

The USGS continues to expand the use of Rapid Deployable Streamgages. These rapidly deployable streamgages provide temporary real-time situational awareness of flood levels to flood-threatened communities that lack permanent USGS streamgages. In 2014, for example, the USGS installed rapidly

deployable streamgages that provided real-time information needed to monitor dangerous river levels for several weeks in the aftermath of the landslide in Orso, WA, in 2014. Streamgages also have been deployed and installed to broadcast data as water levels approach elevations requiring careful management of reservoir releases or levee performance. In 2015, streamgages will be deployed in flood-threatened communities across the Nation during extreme events.

In 2016, as part of the Improving Disaster Response initiative, the Groundwater and Streamflow Information Program would continue to develop flood-inundation mapping libraries and to develop and distribute the RDGs around the Nation, particularly in difficult areas subject to crosswinds, ice-cover, and variable backwater conditions that can severely comprise results.

Research, Development, and Technical Support

(2014 Actual, $6.0million; 2015 Enacted, $6.5 million; 2016 Request, $6.8 million)

The Groundwater and Streamflow Information Program promotes the development and application of new methods, equipment, sensors, platforms, software development, and techniques for monitoring, which results in cost savings and allows the USGS to remain in the forefront of hydrologic observations. The Groundwater and Streamflow Information Program also funds technical support to assure high quality, reliable and reproducible measurements of surface water and groundwater over the full range of hydrologic conditions—at extreme lows and highs—at sites with a high level of certainty and consistency. Specific support is provided for quality control, technology transfer, method and technology development and standardization, priority setting, and management of the USGS Hydrologic Instrumentation Facility (*http://water.usgs.gov/hif/*).

In 2014 and 2015, significant advancements continue to be made in research and technology. For example, the use of hydroacoustic technologies in 2014 and 2015 continued to reduce costs associated with streamgaging and computation and to increase the timeliness and accuracy of the information; the average time of flood measurements was about 15 minutes—a decrease by a factor of five (from nearly 100 minutes) over the past 20 years. Hydroacoustic techniques have improved monitoring of stream velocity and sediment transport, with reduced costs. Nearly all of the top 10 causes of water-quality impairment in streams across the Nation are highly associated with sediment, and solving these issues requires new, innovative monitoring methods.

In 2014 and 2015, the use of remotely sensed information continues to be tested to estimate river bathymetry and water-surface elevations to help in the assessment of hydraulic properties, sediment transport, and bed-evolution in rivers. The new approaches have been tested on many rivers, including the Colorado, Trinity, Missouri, and Russian Rivers to provide information for habitat, restoration, floodplain, and bridge scour applications.

In 2014 and 2015, the USGS continues development and field testing of borehole technology to provide continuous measurements of aquifer porosity and permeability along boreholes and to explore thermal infrared and fiber optic methods to provide insights into groundwater and surface water relations at different scales (through the Office of Ground Water Branch of Geophysics, *http://water.usgs.gov/ogw/bgas/g2t.html*).

In 2016, the Groundwater and Streamflow Information Program would continue to find cost efficiencies in existing monitoring networks and improve capabilities for measuring uncertainties related to the full breadth of hydrologic properties. In addition, the Groundwater and Streamflow Information Program would continue to support the development and application of hydroacoustic techniques to measure streamflow, velocity, and sediment; geophysical and other innovative techniques to measure groundwater; and new techniques for improved observations of surface and groundwater relations. Finally, the Groundwater and Streamflow Information Program plans to expand innovative techniques for observing reservoir capacities, bathymetry, age dating of sediments, and sediment trapping efficiencies. This capability is increasingly important as the USGS tracks impacts of land use and climate change over time.

Information Delivery

(2014 Actual, $2.0million; 2015 Enacted, $2.5 million; 2016 Request, $3.0 million)

The Groundwater and Streamflow Information Program supports the development, implementation, and maintenance of reliable systems for real-time and historic information delivery to all stakeholders that include data processing, quality assurance, storage, and ready available access. The funds ensure the operation and maintenance of the NWIS, which is critical to function at peak efficiency and effectiveness, especially during hazard events. NWIS provides current conditions related to streamflow, flood and high flow, drought, and groundwater levels. The USGS receives, on average, more than a 1.5 million requests for information per day, offering data at more than 1.5 million monitoring sites that span multiple media. In addition, the Groundwater and Streamflow Information Program funds ensure: (1) improved field computing applications, which allow nearly 100 percent digital translation of all site visit data and enhanced consistency, accuracy, and cost savings; (2) new systems that facilitate continuous records processing in a more consistent and streamlined workflow; (3) a new time series processing system (referred to as AQUARIUS Software) used to analyze and manage streamflow data, which will help ensure that streamflow information remains reliable, reproducible, readily accessible, cost-effective, and of a high quality over the full range of hydrologic conditions; (4) Web portals with increased access to nationwide and interdisciplinary USGS information; and (5) applications for immediate delivery of observations on mobile devices. In 2014 and 2015, the USGS receives up to 40 percent of information requests from mobile devices. Increased use of applications include WaterNow (*http://water.usgs.gov/waternow/*), which allows on-demand current conditions for water data directly to your mobile phone or email; WaterAlert (*http://water.usgs.gov/wateralert/*), which is a Web-based, subscriber-customer service used significantly during floods, but also every day for our recreationists who want notification about water levels that have reached an elevation of interest to them; and, finally, USGS Water-Watch pages remain one of our most heavily tapped products, providing current conditions for groundwater levels (*http://groundwaterwatch.usgs.gov/*) and streamflow (http://waterwatch.usgs.gov/). In 2016, the Groundwater and Streamflow Information Program would enhance data processing, quality assurance, storage, and easy data access for real-time and historic streamflow information. Specifically, funding would be directed to enhance data processing, visualization, quality assurance, and auditing through AQUARIUS software. Activities would include training and implementation of the software in USGS Water Science Centers nationwide. In addition, software development would continue to enhance field collection input and user-friendly mobile applications for immediate access to information by USGS stakeholders and society-at-large.

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Activity: Water Resources

Subactivity: National Water Quality Program

2014 Actual: $96.2 million (747 FTE)
2015 Enacted: $94.1 million (741 FTE)
2016 Request: $96.1 million (731 FTE)

Overview

Water-quality monitoring, assessment, and research in the USGS began during the latter part of the 19th century. Initial water-quality investigations were directed toward assessing the suitability of water for domestic consumption, irrigation, and industrial use. Since the early investigations, the USGS has conducted studies directed at a wide range of water-quality issues. Large-scale, long-term monitoring and studies of prominent water-quality issues and detailed, small-scale studies provide critical information for water managers, policymakers and the public about current water-quality conditions, how they are changing through time and the major factors that influence observed conditions and trends. Most of these efforts began in the 1960s and 1970s and were part of the National Stream Quality Accounting Network (NASQAN), Hydrologic Benchmark Network, National Atmospheric Deposition Program, Toxic Substances Hydrology Program, National Research Program, and Cooperative Water Program (CWP).

In 1991, Congress established the National Water-Quality Assessment (NAWQA) Program within the USGS to address a fundamental question: "What is the status of the Nation's water quality and is it getting better or worse?" Since then, NAWQA has been a primary source of objective and nationally consistent water-quality data and information on the quality of the Nation's streams and groundwater. NAWQA data and models provide answers to where, when, and why the Nation's water quality is degraded, and what can be done to improve and protect it for human and ecosystem needs. (*http://water.usgs.gov/nawqa/xrel.pdf*).

"NAWQA's findings have and continue to be used by national, regional, State, and local governments and the private sector to develop more effective, science-based policies and actions to protect and restore water quality. Its findings target actions that can achieve the greatest water quality benefits and can determine whether the billions of dollars invested in pollution control are actually having the anticipated results." Testimony of Matthew J. Millea, Deputy County Executive for Physical Services, Onondaga County, NY representing the Water Environment Federation before the Interior and Environment Subcommittee, Committee on Appropriations, U.S. House of Representatives, April 16, 2013

Beginning in 2016, water quality monitoring, investigations and research done as part of NAWQA, the Hydrologic Bench Network, the CWP, the National Atmospheric Deposition Program, and the National Research Program will be integrated under one program to enhance the linkages and opportunities for collaboration with stakeholders at local, State, regional and national levels. The new National Water Quality Program (NWQP) will continue to deliver data, information and research to: (1) Assess the current quality of the Nation's freshwater resources and how it is changing over time; (2) Evaluate how human activities and natural factors, such as land use, water use and climate change are affecting the

quality of surface water and groundwater; (3) Determine the relative effects, mechanisms of activity, and management implications of multiple stressors in aquatic ecosystems; and (4) Predict the effects of human activities, climate change, and management strategies on future water quality and ecosystem condition. The NWQP will also continue providing leadership to other Federal, State and local agencies through the National Water Quality Monitoring Council to develop collaborative, comparable, and cost-effective approaches for monitoring and assessing our Nation's water quality.

In 2016, the NWQP will be requesting increases in funding to focus on research in ecosystem priorities such as Puget Sound and the Upper Mississippi Basin; groundwater and surface water quality and availability associated with unconventional oil and gas extraction; supporting the NAWQA Cycle 3 work; and supporting the Federal Urban Waters partnership. For more information on these requested funding increases, please see Section C, Program Changes.

Program Performance

National Water Quality Assessment Program

(2014 Actual, $58.8 million; 2015 Enacted, $59.5 million, 2016 Request, $61.6 million)

Two decades of NAWQA monitoring and modeling have resulted in a solid foundation of data and scientific understanding and improved capability within the water community to address current and future water-quality issues. During its first decade (1991-2001 or Cycle 1), the NAWQA Program completed interdisciplinary baseline assessments of the quality of streams, groundwater, and aquatic ecosystems in 51 of the Nation's largest and most important river basins and aquifers. The assessments were based on sampling at 505 stream sites and more than 5,000 wells. During its second decade (2001-2012 or Cycle 2), NAWQA built upon the baseline assessments by reporting on how water-quality conditions are changing over time and by developing regional-scale water-quality models to extrapolate findings to unsampled areas.

"NAWQA has evolved from a water-quality program emphasizing data collection and trend assessments to one that has the potential to predict and forecast pollution occurrence and trends under multiple scenarios at nationally significant scales."
National Research Council (2012, p 158)

For NAWQA's third decade (2013-2023 or Cycle 3), a science plan describing a 10-year strategy for assessing the Nation's freshwater quality and aquatic ecosystems has been developed. The plan continues strategies that have been central to NAWQA's long-term success, but also adjusts approaches, monitoring intensity, and study design to address data and science information needs identified by NAWQA stakeholders and the National Research Council (2012), which reviewed the plan in 2012 (*http://www.nap.edu/openbook.php?record_id=13464&page=R1).* The Cycle 3 plan addresses stakeholder needs for more timely reporting of water-quality information, science, and tools, for example, (1) annual Web-based reporting of concentrations, loads, and trends of nutrients, sediment, and other contaminants in rivers draining into important coastal estuaries; (2) maps showing the distribution of nitrate, arsenic and other contaminants in important water-supply aquifers at the depth tapped by domestic and public-supply wells; and (3) model-based decision-support tools that allow managers to evaluate how

water quality or stream ecosystems may change in response to different scenarios of land use, population growth, or climate change.

In 2015, the National Water Quality Assessment Program received resources to fund ecosystem priority work in the Chesapeake Bay, the California Bay Delta, and the Upper Mississippi Basin. This additional funding will help scientists build upon ongoing monitoring and research to understand how water quality affects the habitat and aquatic and ecosystem health. In 2016, the NWQP is proposing additional funding to continue the investment in the Upper Mississippi Basin. This funding would provide more data collection and interpretative studies on water quality including additional monitoring of nutrients and sediment used to develop water quality models that would help States and local agencies prioritize their efforts towards the largest sources of nutrients in the basin.

Surface Water Quality Monitoring and Modeling

NAWQA (2014, $28.9 million; 2015, Enacted, $29.3 million; 2016 Request, $29.3 million)
Hydrologic Bench Network (2014, $0.5 million; 2015, Enacted, $0.5 million; 2016 Request, $0.5 million)

Restoring and enhancing water-quality monitoring networks, analysis of long-term trends in water quality, and the development of new water-quality models are three high priorities for the surface water component of the NWQP during the next decade. Regional and national monitoring and assessments will continue to focus on nutrients, sediment, pesticides, and other contaminants in agricultural and urban settings in the Mississippi River Basin, in watersheds of other important estuaries, such as the Chesapeake Bay, San Francisco Bay/Delta and Puget Sound, and in other streams and rivers in selected regions.

In 2014, discrete water-quality samples were collected at 102 of the 313 long-term monitoring sites recommended in the NRC reviewed Science Plan for the third decade of the NAWQA Program (Figure 1). The network of sites include long-term monitoring sites sampled by NAWQA during Cycles 1 and 2 as well as selected sites that were part of the National Stream Quality Accounting Network (NASQAN) and the National Monitoring Network (NMN); 10 of these monitoring sites are instrumented with state-of-the-art water-quality sensors that provide real-time, continuous data for nitrate, turbidity, and other characteristics. The USGS is a part of the coalition of Federal agencies, including the Environmental Protection Agency, National Oceanic and Atmospheric Administration, and National Institute of Standards and Technology, that is launching the Nutrient Sensor Challenge in 2015—an open-innovation competition to accelerate the development and deployment of affordable sensors that can measure nutrients in aquatic environments. The more frequent measurements will improve the accuracy of estimated stream nutrient and sediment loads, which are the basis for water-quality models.

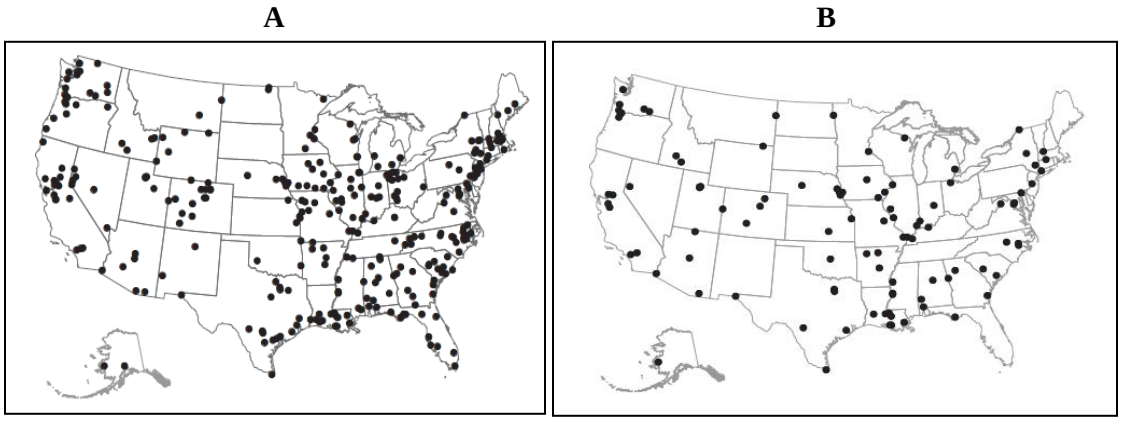

Figure 1. A. Locations of 313 stream and river sites recommended for sampling during Cycle 3
B. Locations of 102 stream and river sites sampled beginning in 2013

Also in 2014, an additional 19 of 36 pristine watersheds distributed across the Nation that have been part of the Hydrologic Bench Network since 1963 were monitored for streamflow, temperature, major ions, nutrients, organic carbon, and other constituents of interest in evaluating long-term changes associated with atmospheric deposition and climate change (Figure 2). Soil chemistry surveys were done in six of the watersheds to better understand its role in our ability to see the effects of changes in the atmospheric deposition loads on stream chemistry. An assessment of trends in water quality in these watersheds covering the period 1970-2010 was completed and published. For streams in the Northeastern United States, there were significant declines in stream sulfate concentrations, which were consistent with declines in sulfate deposition that resulted from reductions in SO_2 emissions mandated under the Clean Air Act Amendments. Declines in sulfate in stream water for the period 1990-2010 were less than two and a half percent per year, which was less than sulfate declines observed in wet atmospheric deposition suggesting that the changes in stream quality are lagging behind the changes in deposition. In 2015, water-quality monitoring will continue at the same network of sites. In addition, the USGS will make an initial release of a new, Web-based, annual reporting tool for stream and river quality data. The major objective of this product is to effectively display and deliver water-quality data in a more timely and consistent fashion than in the past. This non-interpretive product will focus on comparing the most recent year of approved water-quality data for a stream to data collected in previous years.

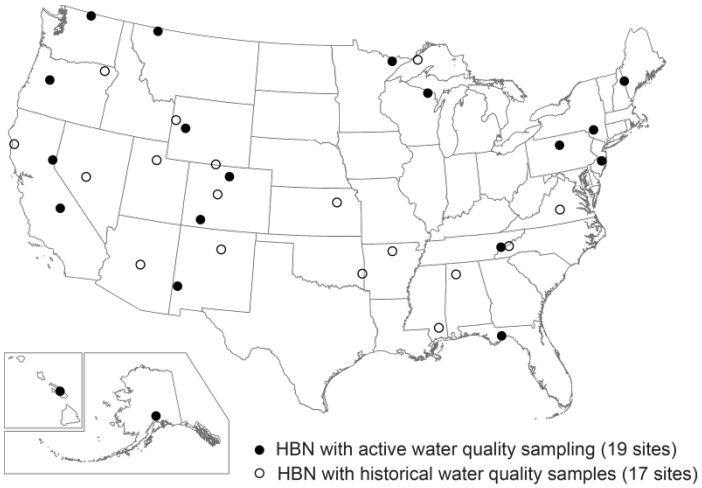

Figure2. Locations of pristine watersheds monitored as part of the Hydrologic Bench Network since 1963 for long-term changes associated with atmospheric deposition and climate change.

In 2016, management and coordination of the 102 long-term water-quality monitoring sites currently sampled by the NAWQA Program for nutrients, sediment, pesticides and other contaminants will be expanded to include the management and coordination of long-term monitoring sites currently supported by the CWP, and Hydrologic Bench Network to form a single National Water Quality Monitoring Network for streams under the NWQP. For example, the additional 19 pristine watersheds sampled by the USGS as part of the Hydrologic Bench Network will be integrated with monitoring at minimally disturbed sites by NAWQA and the CWP to help understand the effects of changes in land use, water use, atmospheric deposition, and climate change on freshwater ecosystems. These reference sites will also be part of the National Network of Reference Watersheds, a collaborative and multipurpose network of watersheds and monitoring sites supported by USGS and the National Water Quality Monitoring Council. Membership in the national network of reference watersheds is voluntary and open to individuals, agencies and institutions supporting monitoring in minimally disturbed and pristine watersheds. In 2016, the USGS will refine tools for users to search and identify reference watersheds suitable for meeting different objectives (*http://my-beta.usgs.gov/nnrw/main/home*).

In 2014, NAWQA presented findings on trends in nutrients and pesticides in the Nation's streams and rivers at a briefing on Capitol Hill in Washington, D.C., cosponsored by the Water Environment Federation and Northeast Midwest Institute (*http://water.usgs.gov/nawqa/headlines/nut_pest/*). One of the key observations was that nitrate concentrations have increased during low streamflows at the outlet of the Mississippi River since the mid1990s—indicating that nitrate concentrations in groundwater that flows into the river and its tributaries may be increasing, thereby contributing to the increasing concentrations in the Mississippi River. Gradually increasing nitrate concentrations in groundwater may represent nitrogen applied to the land surface years or decades ago, suggesting that the full effect of today's management practices may not be observed until many years in the future.

Understanding the causes of water-quality trends in streams and groundwater depends on the availability of reliable information on trends in contributing factors, such as fertilizer use, livestock waste, agricultural management practices, and wastewater treatment improvements. For example, information on these and other factors is needed to better understand what is causing increases or decreases in nitrate

loading to the Gulf of Mexico and other coastal zones of the conterminous United States. The USGS is working with States and other Federal agencies that are part of the Hypoxia Task Force to provide the data and information necessary to develop effective strategies for both groundwater and surface water. In 2014, the USGS and the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service entered into a five-year Memorandum of Understanding to facilitate the development of uniform regional and national geospatial data sets to represent suites of nutrient and sediment reduction conservation practices. The USGS and the USDA will work collaboratively to develop data sets that help to evaluate the efficiency of the conservation actions, but do not reveal privacy information about farms and ranches.

In 2014, historical water-quality data were compiled and evaluated from both USGS sources and hundreds of other agencies and organizations nationwide to provide a data set that could be used to provide a more comprehensive national analysis of long-term trends, and for development of new SPARROW models. The resulting database is one of the most comprehensive ever assembled in the United States, containing data from more than 500 local, State, and Federal agencies. Collectively, the data from a subset of sites with long-term monitoring are expected to provide insight into how natural factors and human activities have contributed to water-quality changes over time in Nation's streams and rivers. During 2015, scientists will refine and apply statistical methods to quantify trends using the data from long-term monitoring sites identified and screened in 2014. Trend results will be summarized regionally and nationally for pesticides, nutrients, sediment, salinity and carbon in 2016, and compared to historical data on changes in land use, climate, point and nonpoint sources, and other major factors to help explain observed trends. Trend results will also be compared to critical aquatic life and human health benchmarks to evaluate progress towards meeting national water-quality goals.

New Web-based SPARROW applications were released in 2014 for mapping nutrient sources to 115 major estuaries along the Atlantic coast, Gulf of Mexico, and Pacific Northwest as well as for 160 watersheds draining into the Great Lakes. The mapping application can be used in the development of nutrient reduction strategies and to inform nutrient policies across the Nation. Additionally, a new national SPARROW model and decision-support system was completed for dissolved solids and a new Web-based portal was completed that provides quality assured, historical USGS suspended sediment data. The availability of an easily accessible, quality controlled database of sediment and associated ancillary data will make it much easier for States and other stakeholders to access the information they need to identify sediment-related water-quality impairments and it is the first step needed for the USGS to develop an improved national SPARROW model for sediment beginning in 2015. During 2016, regional SPARROW models for total nitrogen and phosphorus will be updated using the national databases developed during 2013-2015. The updated models will provide improved capability to predict nutrient conditions in streams throughout the United States reflecting changes to land and water management practices; to identify those areas that contribute the largest amounts of nutrients to downstream receiving water bodies such as the Gulf of Mexico; and to identify the largest sources of nutrients as well as the environmental factors that affect delivery of nutrients to streams.

Groundwater Quality Monitoring and Modeling

(2014 Actual, $15.3million; 2015 Enacted, $15.5 million; 2016 Request, $15.5million)

About 130 million people in the United States rely on groundwater for drinking water, and the need for high-quality drinking-water supplies becomes more urgent as our population grows. Although groundwater is a safe, reliable source of drinking water for millions of people nationwide, high concentrations of some chemical constituents can pose potential human-health concerns. Some of these are natural occurring contaminants that come from the rocks and sediments of the aquifers themselves, and others are chemicals that we use in agriculture, industry, and day-to-day life. When groundwater supplies are contaminated, millions of dollars can be required for treatment so that the supplies can be usable. Contaminants in groundwater can also affect the health of our streams and valuable coastal waters. By knowing where contaminants occur in groundwater, what factors control contaminant concentrations, and what kind of changes in groundwater quality might be expected in the future, we can ensure the availability and quality of this vital natural resource in the future.

NAWQA is the only Federal program that monitors the status of the Nation's groundwater quality and reports on how these conditions are changing over time. In 2014, NAWQA completed eight major reports synthesizing NAWQA groundwater quality assessment findings through 2010 for eight of the Nation's largest and most important principal aquifers, and one report summarizing findings for the Nation. The reports are intended for individuals involved in resource management and protection, conservation, regulation, and policymaking at regional and national levels, as well as the general public. A briefing on Capitol Hill on the major findings is planned for the spring of 2015. Nationally, about one in five wells (22 percent) contained at least one chemical at a concentration greater than a human-health drinking-water benchmark. Most of the chemicals detected at high concentrations are derived from geologic sources, and are released into groundwater as it interacts with the sediment and rocks that comprise the aquifers; examples include arsenic, manganese, and uranium. The reports provide important information on the factors that control the concentrations of contaminants in groundwater including contaminant sources, geochemical conditions, groundwater usage, groundwater age, and geology, which are useful to managers and planners responsible for delivering safe drinking water.

During Cycle 3, NAWQA is planning to sample about 1,500 public-supply wells in 20 Principal Aquifers to provide regional and national contexts for understanding where and why contaminants occur at concentrations that may be deleterious to human health in these deeper systems (Figure 3). NAWQA will also resample about 2,500 relatively shallow observation and domestic-supply wells sampled during Cycles 1 and 2 to assess how groundwater quality conditions are changing over time. The total number of wells to be sampled during Cycle 3 is about two-thirds the recommended number of wells in the NRC reviewed Science Plan. NAWQA's use of broad spectrum laboratory analytical methods that covers a wide range of currently used pesticides, hormones, pharmaceuticals, volatile organic compounds and other contaminants provides the Environmental Protection Agency (EPA), States, and water utilities with critical information about the occurrence of contaminants of emerging concern.

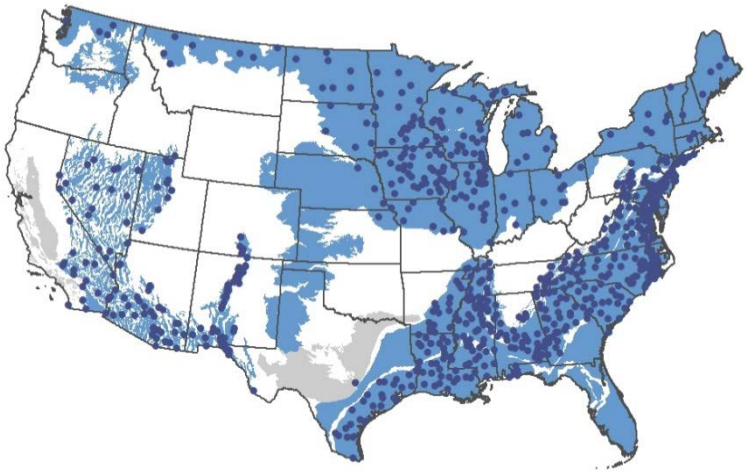

Figure3. NAWQA is planning to sample 1,440 Public supply wells in 20 Principal aquifers during Cycle 3. Areas in lighter color are Principal Aquifers that were or will be sampled from 2013 to 2016, dark color circles are public supply wells sampled by NAWQA in 2013 and 2014, and gray areas are Principal Aquifers to be sampled from 2017 to 2022.

NAWQA sampled 280 public supply wells in five Principal Aquifers in 2014. Wells were sampled in the Glacial (Maine, Massachusetts, Michigan, Minnesota, Montana, New Hampshire, New Jersey, New York, North Dakota, Pennsylvania, South Dakota, Vermont, Washington, and Wisconsin), the Mississippi Embayment (Missouri, Kentucky, Arkansas, Tennessee, Louisiana, and Mississippi), the Piedmont and Blue Ridge Crystalline (Virginia, North Carolina, South Carolina, Georgia, and Alabama), the Cambrian Ordovician (Minnesota, Wisconsin, Michigan, Iowa, and Illinois), and the Rio Grande (New Mexico, Colorado, and Texas) aquifers. In 2015, water-quality samples will be collected from 210 additional public-supply wells in three additional Principal Aquifers: the Floridan (Florida, Alabama, and Georgia), Texas Coastal Uplands (Texas), and High Plains (Colorado, Kansas, Nebraska, New Mexico, Oklahoma, Wyoming, and Texas). In 2016, water-quality samples will be collected from 140 additional public-supply wells in the Biscayne (Florida), Surficial (Alabama, Florida, Georgia, South Carolina), and Columbia Plateau Basalts (Idaho, Oregon, and Washington) aquifers.

In 2014, about 230 additional observation and domestic supply wells that are part of nine networks sampled during Cycles 1 and 2 by NAWQA were sampled again to assess how groundwater quality conditions have changed during the past two decades. Each network typically consists of 20-30 wells randomly distributed over an area. The networks covered areas of California, Indiana, Maryland, North Carolina, Texas, Washington, and Wisconsin. The data obtained from these relatively shallow wells, along with the data from the deeper public supply wells will be used to develop a three-dimensional perspective on regional groundwater quality conditions that can be used by planners and managers to better understand the vulnerability of existing supply wells and guide decisions on the possible placement of new wells. Three additional networks of relatively shallow wells sampled by NAWQA during Cycles 1 and 2 will be resampled in both 2015 and in 2016 to determine decadal changes in water quality.

In 2014, more frequent monitoring (daily, bimonthly, and yearly) was started in two to three wells in each of eight networks located in California, Maryland, New Hampshire, New Mexico, Oregon,

Tennessee, Texas, and Wisconsin to gain perspective and understanding of the magnitude of changes that occur over short time scales relative to those that occur over decades. Data from these eight networks complement the decadal resampling of the 79 networks of observation and domestic wells, and will provide additional context for explaining longer-term trends that are observed. Some changes observed may be due to long-term trends (time-scales at or exceeding 10 years) and others may be due to short-term changes in the hydrologic system). Contaminants that enter an aquifer during a short period of time (less than a year) can remain there for extended periods of time (decades or more).

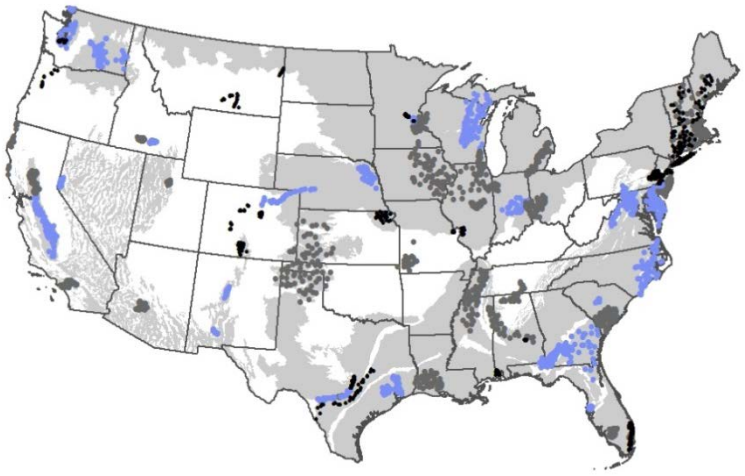

Figure4. Seventy-nine well networks in 20 principal aquifers will be resampled during Cycle 3 to determine how groundwater-quality conditions are changing. Each network consists of 25 to 30 wells in the same principal aquifer spatially distributed (and randomized) across areas ranging from several hundred to several thousand square miles. Nine networks will be resampled in 2014 with a similar number of networks to be resampled in future years. Resampling of 21 other networks proposed in the Science Plan (shown here as black symbols) has been postponed because of funding constraints

In 2014, NAWQA published a Web tool (*http://cida.usgs.gov/gamactt/*) and supporting scientific information that enables resource managers and others to explore, visualize, and explain trends in the quality of groundwater produced from a production well tapping an aquifer receiving non-point contaminants introduced at the land surface. Information from these products will be presented to a variety of drinking-water stakeholders in Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin and California during 2014 and 2015.

Modeling of groundwater quality is an important component of NAWQA's efforts in Cycle 3. These modeling efforts will provide additional insight into the most important factors that affect the vulnerability of domestic and public supply wells to contamination in different aquifer systems and will provide capability to extrapolate water-quality findings into areas of sparse data. Water-quality modeling studies are planned at local, regional and national scales, and are coordinated with the groundwater flow modeling done by the former Groundwater Resources Program (through 2015) and with the Water Availability and Use Program beginning in 2016. Groundwater quality modeling efforts at the regional scale during Cycle 3 are focused on four Principal Aquifer systems: California's Central Valley aquifer system, the Glacial aquifer system that extends across 21 Northern States, the North Atlantic Coastal Plain aquifer system that underlies five Eastern States, and the Mississippi Embayment aquifer system

that underlies six Gulf Coast States. Model results will be used to produce national- and regional-scale maps of contaminant concentrations at the depths of domestic and public supply wells for selected constituents (for example, nitrate and arsenic). Model results will also provide water resource managers with insight into the length of time needed before water quality changes will occur in domestic and public supply wells following changes in climate, water use, and (or) land use. Finally, model results at a regional scale will provide estimates of the contribution of contaminants from groundwater to streams that will be useful in calibration of SPARROW models.

In 2014, 30 wells were sampled in the Glacial aquifer system in Wisconsin to insure that models of the system accurately reflect the three-dimensional distribution of contaminants in the aquifer system, so that observed contaminant concentrations in domestic and public supply wells and the loading of nitrate by groundwater to streams can be explained. In 2016, NAWQA will sample 40 wells in New York and Maryland to support modeling efforts in the North Atlantic Coastal Plain, with particular emphasis on providing an improved understanding of the loading of nitrate by groundwater to the Chesapeake Bay.

Technical and Science Support of USGS Activities

(2014 Actual, $11.0 million; 2015 Enacted, $11.0 million; 2016 Request, $11.0 million)

High quality, nationally consistent monitoring data and information used in reporting of trends and in water-quality models is a signature strength of NAWQA and other USGS water-quality science. To ensure high quality and consistency, national-level training and other forms of technical support for staff scientists on an ongoing basis is critical. Every year, NAWQA supports field methods training for about 40-50 hydrologists and ecologists. For example, in 2014, NAWQA supported training for 27 hydrologists and 19 ecologists in the methods used to collect and process surface water and groundwater quality samples and ecological field methods, respectively.

Following the 2014 chemical spill in the Elk River near Charleston, WV, emergency response agencies and water utilities were unable to determine the extent and degree of contamination accurately because a method to analyze for the contaminants of concern did not exist. Research scientists at the USGS National Water Quality Laboratory, in cooperation with chemists at West Virginia University, developed a new analytical method that enabled agencies and utilities to measure the two chemical forms of 4-methylcyclohexane methanol (4-MCHM), the contaminant of primary concern from the spill, at concentrations less than one part-per-billion which is critical to understanding the contaminant's behavior in the environment and in drinking water systems The USGS collected and analyzed river water samples that showed that the contaminants were still present in the Elk River at low concentrations six days after the spill began and in Charleston tap water more than six weeks after the spill began.

Other essential types of technical support involves quality control of chemical and biological analyses; improvements to the National Water Information System used for storage and retrieval of hydrologic data; and development of the National Hydrography Dataset. These types of activities are ongoing and will continue to be supported in 2015 and 2016.

National Atmospheric Deposition Program

2014 Actual, $1.626 million; 2015 Enacted $1.626 million; 2016 Request, $1.626 million)

Since 1981, the USGS has been the lead Federal agency for the monitoring of wet atmospheric deposition (chemical constituents deposited from the atmosphere via rain, sleet, and snow) in the United States for the interagency National Atmospheric Deposition Program. The USGS supports about one third (77 of approximately 250) of the National Atmospheric Deposition Program-National Trends Network sites which measure acidity, nutrients and other major ions in precipitation. The USGS also supports sites in the 100-site National Atmospheric Deposition Program-Mercury Deposition Network and the National Atmospheric Deposition Program Mercury Litterfall Network. These networks provide scientists, resource managers and policymakers worldwide with long-term, high-quality atmospheric deposition data used to support research and decisionmaking in the areas of air quality, water quality, agricultural effects, forest productivity, materials effects, ecosystem studies, watershed studies, and human health.

In 2014, a National Atmospheric Deposition Program site located at Iberia Research Station in south-central Louisiana, which had operated for 28 years and closed in 2012, was restarted. This site is particularly important for estimating nitrogen deposition to southern Louisiana wetlands, bays and estuaries and is an important site for monitoring deposition of plant pathogens and deposition impacts from atmospheric releases of pollutants in or near the Gulf of Mexico. In 2015 and 2016, all long-term atmospheric deposition monitoring stations will be operated and sustained.

An assessment of historical U.S. atmospheric nitrogen deposition patterns (1955-1984) prior to the full installation of national networks was completed and published. This assessment indicated that atmospheric deposition of inorganic nitrogen increased markedly from the mid-1950s until the early 1980s when the national-scale National Atmospheric Deposition Program network was fully operational. This assessment is also important to current efforts underway in modeling historical nutrient loads in the United States to evaluate nutrient control strategies. In 2015, an assessment to characterize wet atmospheric deposition of major ions, nutrients, and mercury in precipitation along with dry deposition of ammonia and deposition of mercury was started at the National Atmospheric Deposition Program station El Verde, PR, in cooperation with the USDA-Forest Service. Preliminary data has indicated this site has among the highest atmospheric loadings of mercury measured among sites in the National Atmospheric Deposition Program mercury deposition network despite its remoteness from mercury emission sources. This assessment will improve knowledge and understandings of atmospheric loading of mercury and other ecologically important constituents to this sensitive tropical ecosystem. An assessment of the relationship between atmospheric nitrogen deposition and nitrate export in stream water from a high-elevation watershed in Colorado was completed and published. Stream nitrate concentrations increased in the early 1990s, peaked in the mid-2000s, and have since declined by more than 40 percent, coincident with trends in nitrogen oxide emissions over the past decade. Similarities in the timing and magnitude of Nitrogen deposition provide evidence that stream chemistry is responding to changes in atmospheric deposition. In 2016, assessments will be completed and published on (1) the national scale status and trends update on wet deposition to evaluate the response to recent large declines in sulfur and nitrogen emissions, and (2) multi-decade trends in winter snowpack chemistry at high elevation Rocky Mountain sites ranging from New Mexico to the Canadian border. The assessment of trends in snowpack chemistry is important because these high-elevation mountainous areas experience some of the highest levels of

atmospheric deposition (due mainly to high precipitation amounts) and ecological impacts in the Western United States, yet are underrepresented by the standard National Atmospheric Deposition Program stations due the difficulty of operating automated sampling equipment in these harsh and remote environments.

National Park Service Cooperative

2014 Actual, $1.8 million; 2015 Enacted $1.8 million; 2016 Request, $1.8 million)

Since 1998, the National Park Service (NPS) and the USGS have worked together to administer and operate a water-quality partnership program. Projects are developed jointly by USGS and NPS personnel and utilize USGS expertise to support a broad range of water quality science priorities in NPS administered lands. The results from these studies provide Park resource managers with critical information necessary to make sound and scientifically defensible management and policy decisions.

In 2014, six new projects were started with work focused in 14 NPS administered units. Projects provided information to the NPS resource managers on mercury bioaccumulation in Voyageurs National Park (Minnesota) and in Lake Powell–Glen Canyon National Recreation Area (Arizona and Utah); the occurrence, sources and significance of endocrine disrupting compounds and pharmaceuticals in several national park units throughout Colorado and Utah; baseline water quality conditions on lands adjacent to Park areas where energy resource development is expected near the Upper Delaware Scenic and Recreational River (Pennsylvania); and potential climate change impacts that could negatively affect lake water temperature and chemistry within Crater Lake National Park (Oregon).

In 2015, 11 new projects were started in 16 NPS administered units. Projects are providing important information on nutrient loading and impacts from agricultural and other upstream land-use development that could degrade water quality in the Buffalo National River (Arkansas) and Big Thicket National Preserve (Texas); the distribution of bacteria indicators that are of concern to bathers and other recreational users within Tumcacori National Historic Park (Arizona); occurrence and significance of endocrine disrupting compounds across the Southeastern United States, including Big South Fork National River and Recreation Area (Kentucky and Tennessee), Chattahoochee River National Recreation Area (Georgia) and Little River Canyon National Preserve (Alabama); understanding the impacts to water quality and stream biology from dam removal in Olympic National Park (Washington); assessing remediation strategies at abandoned mining sites in Saguaro National Park (Arizona) and identifying hotspots for botulism toxin production at Sleeping Bear Dunes National Lakeshore (Michigan).

In 2016, eight new projects are expected to begin in NPS administered units. Projects are expected to focus on providing the NPS with critical information needed for management decisions to protect and improve water quality and ecosystem health related to historic land use and reclamation, nutrient loading impacts, visitor use impacts and contaminants of emerging concern. In support of the National Park Service 100th anniversary in 2016, USGS projects with innovative science and research that complement centennial goals and events will be prioritized.

Cooperative Water Program

2014 Actual, $17.5 million; 2015 Enacted, $16.5 million; 2016 Request, $16.9 million)

The USGS conducts about 600 interpretative, jointly-planned and -funded studies each year with localities, States, and tribes in all 50 States. These efforts address both short-term issues of emerging concern as well as longer-term issues that require water-quality monitoring, assessment, and research of streams, lakes, and reservoirs and groundwater. For example, in 2014, the USGS and its partners applied cutting edge optical sensor technology in the Mississippi River basin to provide improved estimates of the magnitude and timing of the nitrate pulse (*http://water.usgs.gov/nasqan/nitrate_ms_basin.html*) from small streams tributary to the Gulf of Mexico during spring runoff. The improved estimates of nitrate loads were used to predict the size of the Gulf hypoxic zone, an area with low oxygen known commonly as the "dead zone." Optical sensors provide capability to measure and transmit nitrate data every 15 minutes to three hours and to track how nitrate concentrations from different areas of the watershed are transported in response to rainfall events.

In 2014, with cooperation from 23 local and State agencies, the USGS expanded the use of predictive modeling at 45 beaches throughout the Great Lakes. Local agencies measure fecal-indicator bacteria such as *Escherichia coli (E. coli.)* to estimate concentrations of fecal-indicator bacteria through a predictive modeling approach. Nowcast Web sites provide near real-time information on water-quality conditions at recreational swimming areas. The USGS will continue to collaborate with local agencies to expand Nowcasting to more beaches around the Great Lakes. Using the result of the predictive models and the probability of exceeding the bathing-water standard, beach managers can make more informed decisions on whether or not to close a beach.

In 2015, the USGS is continuing to work with the Milwaukee Metropolitan Sewerage District (MMSD), Wisconsin Department of Natural Resources, Southeastern Wisconsin Regional Planning Commission, the USDA, and local Universities collecting and evaluating hydrologic, geographic, physical, biological, and chemical data for the major streams, and their adjacent corridors within MMSD planning area for use by MMSD to assess the impacts of watercourse improvement practices; assess the quality of Lake Michigan harbors and local waterways within the MMSD service area, of water, wastewater and sediment and how it relates to MMSD's operations and facilities Lake Michigan Harbors and local waterways within the MMSD service area; and to maintain a historical water-quality database.

In 2016, assessments and research on water quality with localities, States, and tribes will remain a high priority of the USGS. Additional focus will be placed on assessing and tracking effects of urbanization (including stormwater, wastewater, and contaminants) on water quality and ecosystem health, as well as tracking improvements in urban water quality through urban management practices, such as green infrastructure. In addition, the USGS will continue advancements in implementing in situ sensors, data platforms, and new techniques to monitor water quality in real time, capturing the variability, such as in seasonal runoff, changes in precipitation intensity, and natural disturbances (such as fire) that can affect the storage, production, and transport of contaminants—including nitrogen and phosphorus—in watersheds and to estuaries and other receiving waters.

Research

(2014 Actual, $10.6 million; 2015 Enacted, $10.6 million; 2016 Request, $10.6 million)

USGS research in water quality is focused on developing an improved understanding of:

- Ecological and biogeochemical processes in aquatic systems to discriminate between natural and human-induced changes and ensure effective water-quality and ecosystem management.
- Chemical and biochemical processes affecting organic and inorganic solutes and gases in aquatic systems in order to evaluate water quality and help managers make informed water-management decisions.
- Stream-channel morphology and erosional processes governing the source, mobility, and deposition of sediment to ensure scientifically based management of rivers, dams and reservoirs.
- Long-term processes in small watershed, including the effect of atmospheric and climatic variables, and provide water and land managers with information needed for water resources management.

Development of new methods and innovative techniques ensures that USGS water-quality science are state-of-the-art and relevant to emerging issues.

In 2014, USGS research scientists used groundwater models and nutrient mass-balance models to evaluate groundwater contributions of nutrients to streams in the Delmarva Peninsula portion of the Chesapeake Bay region. These models were able to reproduce nitrate concentrations in streams and wells over time, including a recent decline in the rate at which concentrations have been increasing. The models were then used to forecast future nitrogen delivery from the Delmarva Peninsula to the Bay under different nitrogen loading scenarios. Under most of the modeled scenarios, groundwater travel times in the aquifers underlying the Delmarva are quite long, suggesting that it will take several decades for the full effects of current and future BMPs targeted at reducing nitrogen loads to groundwater and streams to occur. In 2015 and 2016, modeling similar to that done in the Delmarva Peninsula portion of the Chesapeake Bay region will also be done in the Valley and Ridge portion of the Potomac River Basin. Researchers will finalize a publication that evaluates which methods (chemical, physical, or model-based) work best for estimating the amount of groundwater contributed to streams in the Chesapeake Bay watershed as well as for estimating the lag times between when nitrogen applied to crops, reaches the water table and is transported to streams. These lag times are critical for watershed managers to know so that realistic expectations are set for the effects of BMPs and other nutrient reduction strategies.

Higher-than-expected nitrate concentrations were observed in the Mississippi River in 2013, following 2012 when streamflow was much lower than average. To help determine the reasons for the higher than expected concentrations, USGS researchers developed a new statistical modeling tool that was used to examine the relationship between antecedent flow conditions and nitrate concentrations at eight sites in the Mississippi River basin. The high nitrate concentrations are believed to be due to nitrate accumulation in the soil during drought conditions, followed by flushing of accumulated nitrate into rivers when the drought ended. Conversely, when the previous year's flow was higher than average,

lower-than-expected nitrate concentrations tended to occur because more nitrate had been taken up by crops or removed from the system by denitrification. In 2015 and 2016, the USGS along with scientists from the Johns Hopkins University will collaborate to develop an enhanced statistical model for estimating riverine trends and loads by simultaneously accounting for both current and antecedent flow conditions. Method enhancements will be developed using high-resolution monitoring data from several large river sites.

In 2015, the USGS received an increase in funding to conduct research on carbon cycle modeling. Carbon accounting is needed in a changing world in order to support management decisions that can maximize estuarine resilience and ecosystem services, from carbon sequestration to wildlife support. In 2016, the NWQP is proposing a funding increase to build upon an investment started in 2015 that focuses on carbon cycle modeling in the Nisqually National Wildlife Refuge, and other neighboring field sites (Snohomish Estuary to the north). These areas in the Puget Sound need greater accounting of carbon stocks and fluxes in order to comply with statutory and regulatory requirements.

Understanding the impacts to water resources from unconventional oil and gas (UOG) development is crucial. Some impact to water resources include the contamination of aquifers and surface waters from drilling and hydraulic fracturing chemicals; the cross-contamination of aquifers through faulty well construction and casing installation; the release of methane and other greenhouse gases into aquifers and the atmosphere; contamination from radioactive elements and other toxic chemicals in waters recovered during gas production; and the reduced availability of water, particularly in water-scarce areas. In 2016, the NWQP is proposing a funding increase to build upon an investment of current water quality and water availability research associated with UOG development. The NWQP would continue efforts to examine UOG impacts on groundwater and surface water quality. This research is needed to help understand potential impacts over the entire cycle of UOG operations, and develop best practices and mitigation technologies. In addition, the NWQP would increase its assessment of water quantity needs for the development of unconventional petroleum resources and study how to identify alternate sources of water to replace the use of scarce fresh water. This work would be focused in the Williston Basin, where water resources are scarce and UOG development is proceeding at a rapid pace.

Harmful Algal Blooms

(2014 Actual, $0.5 million; 2015 Enacted, $0.6 million; 2016 Request $0.6 million)

Harmful Algal Blooms are caused by cyanobacteria (blue-green algae) that produce microcystin and other toxins. USGS science is focusing on developing analytical laboratory and field methods to rapidly detect the onset of these blooms and to understand the environmental processes that influence when and where these blooms occur. Current testing methods have been shown to be conservative, thereby leading to unnecessary beach closures and economic impacts from loss of recreational revenues. USGS scientists are working to develop and test affordable and reliable methods to better identify and understand the potential for toxin production in cyanobacterial populations and, at the same time, provide an early warning system for toxin production.

For example, USGS scientists in Ohio are testing the use of optical sensors and quantitative polymerase chain reaction (qPCR), a laboratory method used to detect the presence of the genes associated with the

toxin. During April through November 2014, samples were collected approximately weekly from three recreational lakes. During 2015, sampling will be completed, the data will be analyzed and a report will be prepared. If effective, the early-warning indicators will help water-resource managers make advisory decisions more quickly and cost effectively than by current methods and provide data on when and where to apply more expensive analytical methods.

Similarly, the USGS is working (through 2017) to develop a real-time water-quality notification system for drinking-water suppliers that use the Kansas River as a source-water supply. The Kansas River is important because it is a primary source of drinking water for about 800,000 people in northeastern Kansas. Cyanobacterial blooms typically do not develop in the Kansas River; however, reservoirs in the lower Kansas River basin do occasionally develop blooms. Downstream transport of cyanobacteria and associated toxins and taste-and-odor compounds from reservoirs in the lower Kansas River basin was documented during releases from several reservoirs in 2011. However, the sources, frequency of occurrence, and causes of cyanobacteria, cyanotoxins, and taste-and-odor compounds in the Kansas River have not been fully characterized. The objectives of the ongoing study are to: (1) provide a real-time notification system with sufficient lead time to alert water suppliers that use the Kansas River as a source-water supply of changing water-quality conditions that may affect treatment processes or cause cyanotoxin and (or) taste-and-odor events, and (2) characterize the sources, frequency of occurrence, and potential causes, including fate and transport from upstream reservoirs, of cyanobacteria and associated toxins and taste-and-odor compounds in the Kansas River.

Urban Waters Federal Partnership

(2014 Actual, $0.0 million; 2015 Enacted, $0.0 million; 2016 Request, $0.7 million)

The USGS is partnering with other Federal, State, and local agencies to help reconnect urban communities, particularly those that are economically distressed, with their waterways by improving coordination among Federal agencies and collaborating with community-led revitalization efforts to improve our Nation's water systems and promote their economic, environmental and social benefits. USGS scientists are involved in all seven of the original pilot areas for the Urban Waters Federal Partnership including: Anacostia Watershed, Washington, D.C.; Patapsco River Watershed, Baltimore, Maryland; Harlem-Bronx River Watershed, New York; Lake Pontchartrain Area, New Orleans, Louisiana; Lake Michigan/Little Calumet River, Indiana; South Platte River, Denver, Colorado; and Los Angeles River Watershed, California.

In 2014, the USGS is partnering with Montgomery and Prince George's Counties in Maryland, and the District Department of the Environment to monitor five surface-water quality sites in the non-tidal tributaries of the Anacostia River. Samples are being collected to assess concentrations of nutrients, sediment, bacteria, chloride, and metals and monitors have been deployed to record physical parameters such as temperature, turbidity, pH, conductivity, and dissolved oxygen in the streams, and display the data in real time on USGS Web sites. These data are used to estimate contaminant loading from the watershed and to assess permits for municipal separate storm sewers.

In 2015 and 2016, the Federal partnership will expand the effort to include 11 new urban areas including Albuquerque/Middle Rio Grande, New Mexico; Atlanta/Proctor Creek Watershed, Georgia;

Chelsea/Everett/North of Boston, Massachusetts/Mystic River Watershed; Grand Rapids/Grand River, Michigan; Kansas City/Middle Blue River, Missouri; Passaic, Passaic River, New Jersey; Philadelphia and Chester, Pennsylvania, Wilmington, Delaware, and Camden, New Jersey/Delaware River Watershed; San Juan/Martin Pena Channel, Puerto Rico; Seattle/Puget Sound - Green - Duwamish Watershed, Washington; St. Louis /Meramec and Big River Watersheds, Missouri Toledo/Western Lake Erie Basin, Ohio.

The USGS is working with the University of Pennsylvania's Wharton School to develop a research agenda on topics related to urban ecosystem services and America's Great Outdoors including urban waters for the urban study area in and around Philadelphia. Studies relating to urban forests, green infrastructure, criteria for coastal storm protection (in partnership with the EPA), and incentives for urban ecosystem services (in partnership with the USDA) are being assessed and/or developed.

In 2016, the NWQP is requesting a funding increase for the Urban Waters Federal Partnership to focus on enhancing water quality, water quantity, and habitat monitoring; supporting studies to understand the use of green infrastructure to reduce the impact of stormwater runoff; and developing modeling tools to simulate water quality, biological conditions, and to describe stream health.

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Activity: Water Resources
Subactivity: Water Resource Research Act Program

2014 Actual: $6.5 million (2 FTE)
2015 Enacted: $6.5 million (2 FTE)
2016 Request: $6.5 million (2 FTE)

Overview

Mission: The *WRRA Program* plans, facilitates, and conducts research to aid in the resolution of State and regional water problems. The program promotes technology transfer and the dissemination of research results while providing for the training of the next generation of scientists and engineers through their participation in research.

The Water Resources Research Act (WRRA) of 1984 established a Federal–State partnership in water resources research, education, and information transfer through a matching grant program. The WRRA authorized the establishment of State Water Resources Research Institutes (National Institutes for Water Resources) at land grant universities across the Nation. There are 54 Institutes: one in each State, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and Guam. The Guam institute also serves as the Federated States of Micronesia and the Commonwealth of the Northern Mariana Islands. The WRRA Program provides an institutional mechanism for promoting State, regional, and national coordination of water resources research, promotes student education and training, and is a focal point for research coordination and information and technology transfer. This program will continue to support each Institute and coordinate multi-year research, education, and information transfer projects on State and regional water resources issues. The WRRA expired in 2011 and requires reauthorization.

WRRA Program components include:

- Annual Base Grants (42 U.S.C. § 10303 (104(b))) – In 2014, $3.7 million of USGS appropriated funding dollars plus an Institute match of $7.4 million dollars funded 230 research projects to address State and regional water problems. These projects addressed the entire spectrum of water issues and were used by water managers and the public to improve water quality, water treatment technologies, and water supply reliability at the State and regional level. These research projects directly supported student education by training scientists and engineers through their participation in research (*http://water.usgs.gov/<wrri/annual-base-grants.php*). Currently, all research projects funded by annual base grants are selected at the Institute level through a competitive selection process that is run by each Institute within their respective States. Research projects funded will meet the goals of the WRRA, and will also promote the national mission and objectives of the USGS that focus on water quality and quantity information, understanding water availability, addressing the influence of climate on water resources, and responding to water-related emerging needs. In 2015, the USGS will consult with the institutes regarding management and funding strategies to support more effective leveraging of base funding across States and regions, optimizing national water science and technology priorities, and enhancing the performance of the institutes. Among the strategies that will be considered are possibly converting operational base funding for the institutes and grants from a formula basis to a

national competitive process. Upon consultation with the institutes, changes in the program would be implemented in 2016.

- National Competitive Grants (42_U.S.C.§ 10303 (104(g))) – This program component supports an annual call for proposals to focus on water problems and issues that are of a regional or interstate nature or relate to a specific program priority identified by the Secretary of the Interior and the Institutes. Total funding in 2014 was just under $1.0 million and funded four research projects to study: (1) residential damage associated with inland flooding from North Atlantic tropical cyclones; (2) effectiveness of urban stormwater best management practices; (3) effects of exposure of hormones and emerging contaminants to fish in the Chesapeake Bay watershed; and (4) and the mobilization of naturally occurring uranium in groundwater. Additional information on these projects may be found at the Web site (*http://water.usgs.gov/wrri/national-competitive-grants.php*). In 2015 and 2016, the WRRA Program will promote collaborations between the USGS and University scientists in research on significant national and regional water resources issues. USGS appropriated funds would be used to fund USGS scientists to collaborate on University research proposals that are selected through the competitive process.
- Coordination Grants – These noncompetitive grants authorized by the WRRA allow the USGS and other Federal agencies to use the expertise and capabilities that are available through the network of Institutes. In 2014, the USGS issued 15 new coordination grants ($1.3 million) in cooperation with other USGS programs (eight grants), the Environmental Protection Agency (two grants), and the U.S. Army Corps of Engineers (five grants). Additional information on these projects may be found at the Web site (*http://water.usgs.gov/wrri/coordination-grants.php*). Typically, the USGS issues between 10-15 coordination grants per year. In 2015 and 2016, the USGS anticipates issuing at least 10 new coordination grants per year.
- Student Internships – In cooperation with the National Institutes for Water Resources, the WRRA Program coordinates student interns to provide undergraduate and graduate students with career field, laboratory, and research experience through participation in USGS activities as interns. In 2014, 12 students participated in new and ongoing internships throughout the Nation. Featured student internship projects along with a listing of all internships may be found at the Web site (*http://water.usgs.gov/wrri/student-internships.php*). Typically, the USGS supports 10-12 student interns per year. In 2015 and 2016, the USGS anticipates supporting at least 10 interns per year.

In 2014, the WRRA Program supported research projects that addressed water issues relating to water availability, advances in water infrastructure, improvements in water quality, and advances in water treatment technologies and efficiencies. Many projects with the potential to advance water infrastructure were focused on new and more efficient techniques for water quality monitoring. Several projects that address treatment technologies were directed toward in situ treatment of groundwater.

Program Performance

Preserving Wetland Health – The health of wetland ecosystems depends on many factors, including fluctuations in the amount of available groundwater and water that has been lost to evapotranspiration.

Those are two unknowns in any water budget and are often ignored in regional groundwater flow models. In 2014, the Montana Water Center began using the Gartside Reservoir prairie fen to model groundwater availability and evapotranspiration, and develop methods for defining the aquifer conditions affecting evapotranspiration.

Treating Coal Mine Drainage with Bacteria – One of the most serious water-quality problems in the Appalachian coal mining regions is acid mine drainage (AMD), where high levels of acid and iron can create long stretches of "dead" streams. In 2014, the Ohio Water Resources Center discovered that adding certain bacteria to AMD speeds oxidation and removes the iron, a discovery that could lead to an inexpensive, efficient and sustainable solution to treating AMD.

Carbon Runoff from Hurricanes – In addition to the physical damage from hurricanes, researchers at the Delaware Water Resources Center are finding that hurricanes can have dramatic consequences on the environment as well. The research team studied carbon levels in stream runoff over a 16-month period that included Hurricanes Nicole, Irene and Sandy. They concluded in 2014 that particulate carbon levels were six- to eight-times higher than dissolved organic carbon levels. Such shifts in the proportion of carbon forms entering streams, lakes and rivers can have serious effects on ecosystems and human health.

Program Evaluation – In 2014, a comprehensive programmatic Institute evaluation was conducted on all 54 Institutes to determine their eligibility for continued support under the WRRA. The programmatic evaluation is conducted at least once every three years. The determination of continued support was based on each Institute's effectiveness in the use of its Federal grant dollars and required matching funds in meeting the mandates of the WRRA. Fifty-three of the 54 Institutes passed and were deemed eligible for continued support under the WRRA, with one Institute placed on probation. The one Institute placed on probation has one year to correct the deficiencies determined by the evaluation panel. The evaluation panel was composed of: (1) a Department of Interior employee; (2) University or other professional with experience in conducting water resources research; (3) former Director of a Water Resources Research Institute; and (4) University faculty or other professional with relevant experience in information transfer.

New Web Site – During 2014, a new public Web site for the WRRA Program was developed that highlights program accomplishments, describes the program components, lists the awarded grants associated with each program component and displays the products associated with each grant (*http://water.usgs.gov/wrri/index.php*).

Competitive Grants – In 2016, the USGS plans to further refine the Request for Proposal to further the goals of the WRRA and the Strategic Directions for USGS Water Science Strategy (*http://pubs.usgs.gov/of/2012/1066/*). Specific areas of research that overlap include: (1) providing society the science it needs regarding the amount and quality of water in all components of the water cycle; (2) advancing our understanding of processes that determine water availability; and (3) predicting changes in the quantity and quality of water resources in response to changing climate, population, land use, and management scenarios.

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Core Science Systems

Activity: Core Science Systems

		2014 Actual	2015 Enacted	2016 Fixed Costs and Related Changes (+/-)*	2016 Internal Transfer	2016 Program Changes	2016 Budget Request	Change from 2015 (+/-)
Science Synthesis, Analysis, and Research ($000)		24,314	24,299	248	0	1,350	25,897	1,598
	FTE	102	98	0	0	0	98	0
National Cooperative Geologic Mapping Program($000)		24,397	24,397	242	0	700	25,339	942
	FTE	112	112	0	0	2	114	2
National Geospatial Program ($000)		60,096	58,532	690	0	16,509	75,731	17,199
	FTE	302	260	0	0	6	266	6
Total Requirements ($000)		**108,807**	**107,228**	**1,180**	**0**	**18,559**	**126,967**	**19,739**
Total FTE		**516**	**470**	**0**	**0**	**8**	**478**	**8**

**Fixed Costs are $1,122 and Seasonal Federal Health Benefits are $58*

Summary of Program Changes

Request Component	($000)	FTE	Page
Science Synthesis, Analysis and Research	**1,350**	**0**	
Big Earth Data: Observations and Measurements	500	0	C-49
Ecosystem Services: Decision Support Tools	300	0	C-47
Pollinators	350	0	C-27
WaterSMART: Drought	200	0	C-14
National Cooperative Geologic Mapping Program	**700**	**2**	
Natural Hazard Science for Disaster Response: Sinkhole Response	200	0	C-40
Resilient Coastal Landscapes and Communities: Sea-level Rise Models	500	2	C-32
National Geospatial Program	**16,509**	**6**	
3D Elevation: Alaska Mapping and Map Modernization	1,322	3	C-51
3D Elevation: Coastal lidar	500	0	C-52
3D Elevation: National Enhancement	1,387	0	C-51
3D Elevation: NHD/Landscape Level Assessments - Chesapeake Bay	500	0	C-51
Community Resilience Toolkit	11,000	0	C-63
Critical Landscapes: Columbia River	350	0	C-22
Critical Landscapes: Puget Sound	450	0	C-23
WaterSMART: National Hydrography Database	1,000	3	C-9
Total Program Change	**18,559**	**8**	

Justification of Program Changes

The 2016 Budget Request for Core Science Systems (CSS) is $126,967,000 and 478 FTE, a net change of +$19,739,000 and +8 FTE from the 2015 Enacted level. For more information on the CSS Mission Area changes, please see Section C, Program Changes as indicated in the table.

Activity Summary

As part of the Nation's largest water, Earth, and biological science and civilian mapping agency, the CSS Mission Area conducts national-focused Earth-system science to deliver an understanding of the Earth's complex geologic structure. CSS conducts core sciences across a broad range of fields from structural geology, geomorphology and geophysics, to geography and remote sensing, evolutionary biology and biogeography. Products include interpretive studies, scientific publications, three-dimensional geologic

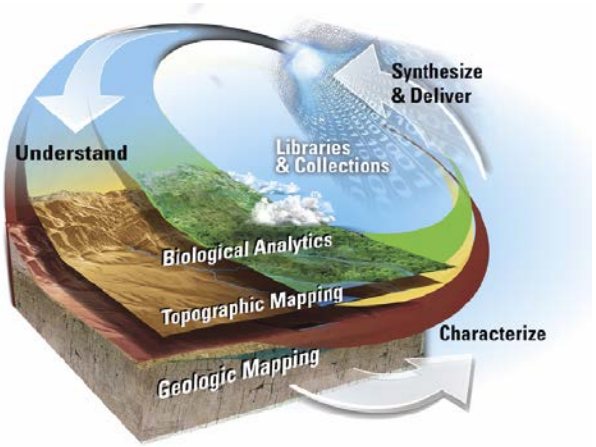
models, fundamental geospatial data, geologic and topographic maps, all of which are essential for informed public policy decisionmaking and economic development.

Modern mapping includes Earth observations from many platforms (such as satellite, airborne, and unmanned aerial vehicles) and uses continuously evolving technologies that can sense and map an expanding list of features, such as gravity, magnetism, and thermal signatures using the latest technologies. Through collaborative efforts with Federal, State, tribal and local partners, CSS delivers nationally consistent, high-quality geologic, topographic, and biogeographic information. Detailed, accurate information about the nature and origin of the geology of an area, portrayed through geologic maps and three-dimensional frameworks, is essential for identifying mineral, oil, and gas resources, finding and protecting groundwater, guiding earthquake damage prediction, identifying landslide and post-wildfire hazards, guiding transportation planning, and generally improving the quality of life and economic vitality of the Nation. Highly accurate elevation maps and data, for example, are essential for hazards mitigation, conservation, infrastructure development, national security, coastal shoreline erosion, and many other applications. The benefits apply to flood risk management, agriculture and precision farming, water supply, homeland security, renewable energy, aviation safety, and other activities.

CSS science supports the Department of the Interior's (Interior) 2014–2018 Strategic Plan Mission Area – Building a Landscape level Understanding of Natural Resources and other Administration and Interior priorities by:

- Providing foundational data layers for geology, topography, and biogeography.
- Advancing a landscape-level understanding of natural resources through the Geospatial Platform.
- Engaging the next generation of geologic mappers—more than 1,100 college geoscience students to date.
- Systematically enhancing elevation data over the conterminous United States, Hawaii, Alaska and the territories through the 3-D Elevation Program (3DEP).
- Acquiring and enhancing foundational digital map layers such as elevation, surface water, and boundaries that will be used to produce new US Topo maps for Alaska.
- Managing the U.S. Node of the *Global Biodiversity Information Facility* (GBIF), which serves as an integral part of *EcoINFORMA*, the information delivery strategy in "*Sustaining Environmental Capital: Protecting Society and the Economy*," a report by the President's Council of Advisors on Science and Technology (*PCAST*).

The Critical Zone



The *Critical Zone* concept, introduced by the National Research Council in 2001, is the seamless collection of all ecosystems that sustain life on the planet and is the area where humans interact with and often compromise ecosystem functions. The figure depicts the key elements of the Core Science Systems mission.

CSS's Strategic Plan, *U.S. Geological Survey Core Science Systems Strategy – Characterizing, Synthesizing, and Understanding the Critical Zone through a Modular Science Framework*, outlines three broad goals for the coming decade:

1. Provide research and data to characterize and understand the Critical Zone.
2. Expand USGS research applications through scientific services,
3. Conduct scientific analysis and synthesis to improve coverage, scientific quality, usability, and timeliness of information.

The CSS Mission Area uses its information resources to create a more integrated and accessible environment for existing and new USGS data resources and participates in building global integrated science platforms.

CSS leads the USGS in the development and implementation of national standards for in the creation, management, and dissemination of digital Earth systems information to stakeholders. CSS includes the following subactivities and science efforts:

Science Synthesis, Analysis, and Research (SSAR) supports the entire science life cycle. This subactivity is comprised of the J.W. Powell Center for Analysis and Synthesis; the National Geological and Geophysical Data Preservation program; and the Core Science Analytics, Synthesis, and Library program. SSAR provides unique scientific collaborative opportunities, and preserves and makes available rock and ice core samples for scientific research. These programs maintain a comprehensive and up-to-date compilation of data about U.S. land in conservation status, enhancing CSS's ability to advance the USGS Science Strategy by developing, identifying, and implementing best practices for accessing, integrating, visualizing, and delivering USGS data and information. For more information, go to:

Core Science Analysis, Synthesis, and Library - *http://www.usgs.gov/core_science_systems/csas/*

The Libraries - *http://library.usgs.gov/*

Data Preservation Program - *http://datapreservation.usgs.gov/*

J.W Powell Center for Analysis and Synthesis - *http://powellcenter.usgs.gov/*

The National Cooperative Geologic Mapping Program (NCGMP) cooperates with State geological surveys to provide publications, digital geologic maps, and multidimensional models and visualizations to sustain and improve the quality of life and economic vitality of the Nation and to mitigate natural hazards. Of note, the program makes geologic mapping data, from all of North America, publically and freely available by way of the National Geologic Map Database. Recently, the program marked the 22st anniversary of the National Geologic Mapping Act that established the NCGMP and the partnership with State geological surveys and universities. Since its inception, the program has leveraged more than $113.0 million in Federal funding matched by the State geological surveys to collaboratively produce modern geologic maps for the Nation and $8.7 million matched by universities to train the next generation of geologic mappers—more than 1,100 college geoscience students to date.

For more information, go to:

NCGMP main program page - *http://ncgmp.usgs.gov/*

The National Geologic Map Database - *http://ngmdb.usgs.gov/ngmdb/ngmdb_home.html*

FEDMAP component - *http://ncgmp.usgs.gov/about/fedmap.html*

STATEMAP component - *http://ncgmp.usgs.gov/about/statemap.html*

EDMAP component - *http://ncgmp.usgs.gov/about/edmap.html*

Federal Advisory Committee - *http://ncgmp.usgs.gov/about/evaluation/faca_intro.html*

The National Geospatial Program (NGP) provides the Nation with base geospatial data. The baseline is The National Map, a set of databases of map data and information from which customers can download data and derived map products for free using Web map services. The program acquires geospatial data, conducts quality control and assessment of the data; manages and publishes these high quality data and maps of the Nation's topography, natural landscape, and built environment. Agencies and the private sector incorporate these data and maps into their business activities and applications. Well-known companies that take the USGS topographic data and use them in their business application products and services include Google Maps, Bing Maps, and ESRI. Applications use National Map data for understanding seismic and landslide hazards and forecasting floods; analyzing and mitigating coastal erosion and storm surge; improving aviation safety; enabling precision agriculture; water quality analyses, quantity, and use; and topographic maps essential for scientific fieldwork, and provide a base onto which geology and other scientific data can be overlain. The USGS partners with other agencies to leverage funding to acquire new geospatial data through the private sector. Leveraging agency funds provides data to all partners at lower unit costs, ensures that industry standards are followed, and places them in the public domain. The program publishes these standardized data allowing their reuse, which reduces future duplication of data acquisition efforts. For more information, go to:

Geospatial liaison site at *http://liaisons.usgs.gov/geospatial/*

The National Map site - *http://nationalmap.gov/*

US Topo site - *http://nationalmap.gov/ustopo/index.html*

US Board on Geographic Names site - *http://geonames.usgs.gov/index.html*

Hazards Data Distribution System site - *http://hdds.usgs.gov/hdds2/*

The National Map viewer and download platform site - *http://nationalmap.gov/viewer.html*

The National Atlas of the United States of America® site - *http://www.nationalatlas.gov/*

Historical Topographic Map Collection site - *http://nationalmap.gov/historical/index.html*

Geospatial Research - *http://cegis.usgs.gov/*

The Federal Geographic Data Committee (FGDC) promotes and endorses consistent data and metadata standards, system interoperability, and cross-government best business practices for geospatial resources,

policies, standards, and technology in support of the National Spatial Data Infrastructure. The FGDC Office of the Secretariat, administered by the USGS, provides support to the FGDC Chair and Vice Chair, the 32 member agencies, and Federal geospatial initiatives and priorities that enhance information availability for decisionmaking and science, increase information delivery efficiencies, and reduce duplication of Federal Geospatial data assets through shared services to leverage economies of scale. The Geospatial Platform is an Internet-based capability that provides a suite of well-managed, highly available, and trusted geospatial data, services, and applications for use by Federal agencies and their State, local, tribal, and regional partners. The Geospatial Platform supports the Secretary's Landscape Level Understanding priority and serves as the delivery mechanism for Federal geospatial portfolio assets and the integration point for leveraging shared information from, and with, other State, local, tribal, and non-governmental information sources. This approach provides increased return on existing geospatial investments by promoting the reuse of data, applications, and tools. For more information, go to:

Federal Geographic Data Committee, Office of the Secretariat – http://www.fgdc.gov/

Geospatial Platform – *http://www.geoplatform.gov*

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Activity: Core Science Systems

Subactivity: Science Synthesis, Analysis, and Research

2014 Actual: 24.3 million (102 FTE)
2015 Enacted: 24.3 million (98 FTE)
2016 Request: 25.9 million (98 FTE)

Overview

Science Synthesis, Analysis, and Research (SSAR) provides analysis and synthesis of scientific data and information, and long-term preservation of scientific data and library collections. SSAR ensures that data are strategically managed, integrated, and available to decisionmakers and others as they focus on issues associated with Earth and life science processes. SSAR includes the J.W. Powell Center for Analysis and Synthesis (Powell Center); the National Geological and Geophysical Data Preservation (NGGDP) program; and the Core Science Analytics, Synthesis and Library program (CSASL).

Program Performance

USGS Grants Ensure Important Data Preservation and Fund Students – In 2014, the NGGDP awarded grants to 30 States to preserve a wide array of valuable geoscience data. Through this program, many States are making great progress to preserve and provide access to fragile and one-of-a-kind materials. In many instances, the State collections continue to provide access to information currently not available or accessible in the field due to land-use or permission changes of geologically important sites. State collections are well-organized and accessible to ensure access to materials and data that would otherwise cost tens of thousands to millions of dollars to reproduce or collect. For example, several States have facilities and collections that are used in training of the next generation of geoscientists. Along these lines, at least one State has a collection that represents some of the most important work done by early American geologists and forms the basis for much of the subsequent work on Precambrian rocks in the Lake Superior region. Geologically, this work represents one of the most comprehensive surveys done in the region and has resulted in an irreplaceable collection of hand samples and thin sections. Capturing metadata for them and providing access to the physical samples and to the information in their associated documents benefit historians and geologists throughout the country. Projects funded in 2014 have societal benefits and can be separated into three major categories: science, industry/resource management, and environmental safety and health. Nationwide, including matching State funds, $1.6 million was contributed to these efforts. This includes approximately 19,000 student hours. It is estimated that $0.8 million will be awarded to 25–30 States in 2015 and 2016 to inventory collections of geological and geophysical data, create metadata for individual items in those data collections, create or update digital infrastructure, and rescue data at risk.

Big Earth Data Initiative and Open Data Policy – The USGS is leading Interior in the Big Earth Data Initiative (BEDI), working in concert with the Office of Science and Technology Policy, the National Oceanic and Atmospheric Administration, NASA, the U.S. Department of Agriculture, the Environmental Protection Agency, and the Department Of Energy (DOE), with Core Science Systems co-chairing the USGEO Data Management Working Group. Through efforts in response to the Open Data Policy, early successes were achieved for the data discoverability aspects of BEDI, including developing the USGS Science Data Catalog, Interior's public data listing, and Data.gov where 28 of the 60 observing systems affiliated with Interior are now represented through cataloged metadata. Foundational USGS data management policies were developed and approved. The USGS Science Data Catalog provides a consolidated access point for USGS science data that is organized and searchable. The USGS ScienceBase provides the underlying metadata management infrastructure for the Science Data Catalog, and its repository services capability provides a method of making currently offline or only downloadable data available as Web services—the key method of increasing accessibility in BEDI.

Powell Center Drives Interdisciplinary Research Across Scientific Community – The John Wesley Powell Center for Analysis and Synthesis (Powell Center) brings together leading scientists from multiple scientific disciplines to address complex, high impact societal challenges associated with major Earth science issues. In 2014, Powell Center working groups published over 20 scholarly articles, many in high profile scientific journals. These articles document studies related to significant scientific challenges, and routinely garner a high number of citations and drive debate in their respective fields. 2014 examples include—

- An analysis of the recovery of riverine ecosystems following removal of dams – this work will help prioritize future dam removal and maintenance planning, and establish best practices for managing ecosystem recovery following removal of dams.
- Design of a data system documenting crustal fluid flow, integrating millions of independent measurements of crustal properties, and serving as a precursor to a complete Digital Crust allowing detailed scientific examination of the Earth's surficial geology.
- A national valuation of monarch butterflies, documenting cultural and economic value of monarchs, and examining potential international market-based conservation strategies.

The Powell Center supports scientist-driven interdisciplinary analysis and synthesis of complex natural science issues.

EcoINFORMA (Ecoinformatics-based Open Resources and Machine Accessibility) – EcoINFORMA is the strategy for making Federal environmental data freely available and highly interoperable. USGS leadership, in interagency activities through the National Science and Technical Committee's Working Group on Biodiversity and Ecosystem Informatics, laid the groundwork to complete the full implementation of EcoINFORMA in 2014, and plans an Interior-level release of the system in 2015. Environmental data can now be re-used and mixed and matched in new ways to build an application, start a business, do new scientific investigations, or just find the best fishing or duck hunting spots. The President's Council of Advisors on Science and Technology, which includes top scientists and executives from Google and Microsoft, recommended the strategy to make Federal environmental data more available and useful. Federal agencies across the government are implementing it. Data access is at a

new top-level Data.gov community (Ecosystems.Data.Gov), which fosters integrating map-based data in new ways and save and share products in a new Federal Geoplatform viewer (www.Geoplatform.us). For example, users can explore Biodiversity at Biodiversity Information Serving Our Nation (bison.usgs.ornl.gov) or Ecosystem Services at the EnviroAtlas (enviroatlas.epa.gov), or Land Cover and Land Use Change at the Multi-Resolution Land Cover Characteristics Consortium (*www.mrlc.gov*). Continued build out of the system in 2015 will make environmental data from across the Federal government readily available and useful for business, academia, and all levels of government.

The John Wesley Powell Center for Analysis and Synthesis

(2014 Actual, $0.1 million; 2015 Enacted, $0.3 million; 2016 Request, $0.3 million)

The Powell Center serves as a catalyst for innovative thinking in Earth system science research focusing on multi-faceted issues, funding interdisciplinary Working Groups to investigate discrete, high-impact scientific challenges. The scientist-driven center, which provides unique opportunities for collaboration among government, academic, and industry scientists, completed its fourth full year of operation in 2014. In 2014, the Center received 29 proposals for potential funding, an increase of over 50 percent from 2013. The Powell Center Science Advisory Board, made up of leading scientists from many disciplines both within and outside the USGS, selected four new Working Groups from this pool. These will join 11 continuing Working Groups, for a total of 15 active Groups. The newest Working Groups focus on major scientific questions, including earthquake forecasting, geographically isolated wetlands, landscape genomics, and stream productivity and carbon cycling. The Powell Center continues to expand its partnership with the National Science Foundation (NSF), adding new NSF representatives onto the Science Advisory Board and undertaking high level discussions with NSF to coordinate joint funding of Working Groups. Powell Center Working Groups have published over 40 scientific articles since the Center's inception, including publications in the *Nature Climate Change* and *Science*. In 2015, the Powell Center will continue to provide opportunities for scientific collaboration through the Working Groups, while expanding on the work of previous and ongoing Working Groups investigating hydraulic fracturing.

Data Preservation

(2014 Actual, $2.1 million; 2015 Enacted, $2.1 million; 2016 Request, $2.1 million)

National Geological and Geophysical Data Preservation (NGGDP) program efforts are dedicated to the preservation of physical geoscience samples, and analog and digital geoscience data including rock and ice cores, fossils, fluid samples of oil, gas, and water, and geochemical samples. This information populates the National Digital Catalog of archived materials to include inventories of geological and geophysical data collections and metadata on individual items within those collections. To accomplish this work, the USGS cooperates with State geological surveys and other Interior bureaus.

Preserving endangered geological and geophysical collections is more cost effective than recollecting this information, while also ensuring that research data collected in the past can be reused, and integrated into new research in the future. The USGS ensures information and data are cataloged and organized in storage areas that are well designed data repositories. Many Federal and State geological repositories are at or near capacity and unable to accept additional materials. The NGGDP supports the development of

national standards, procedures, and protocols for preserving collections and improving their accessibility for current and future researchers. By working together to manage and make these research inputs accessible, the USGS and its partners can leverage the work of their colleagues and provide new insights in context with the scientific record.

In 2015, the NGGDPP will boost efforts with States to inventory and preserve a wide array of important geoscience data and collections. States are making strides to preserve and provide access to fragile and one-of-a-kind materials. Many State collections provide access to information currently not available or accessible in the field. Collections from each State typically provide access to materials and data that would otherwise cost tens of thousands to millions of dollars to reproduce or collect. Projects funded in 2014 are associated with three major categories: science, industry/resource management, and environmental safety and health. This collaboration improves the National Digital Catalog enabling better methods to find, get and use preserved geoscience data. The National Digital Catalog is comprised of over 750 collections, representing nearly 2,700,000 geoscience data points, provided by 44 States and USGS collections. These resources contribute to expanding digitization, description, and accessibility of research products in possession of the USGS and its partners for the broader availability of this content for integration and discovery. Resources contribute to increasing digitization, description, and accessibility of research products allowing for content integration and discovery.

Included in Data Preservation are two essential repositories:

Core Research Center (CRC) – Established in 1974, the CRC preserves valuable rock cores for use by scientists and educators from government, industry, and academia. Rock cores and drill core cuttings are permanently stored and available for examination and testing at the CRC in Denver, CO. Because of this storage capability, billions of dollars are saved by not re-drilling and replicating collections. The drilling cost to replicate these collections is conservatively estimated to be in excess of $30 billion. The CRC is currently one of the largest and most heavily used public core repositories in the United States. The CRC also houses, in volume, the second largest Federal fossil collection in the United States. The fossil curation staff has conducted digital georeferencing on over 35,000 fossil localities, thus making these portions of the databases projectable in mapping and commercial software. Accurate geolocation allows scientists to use the fossils for an enhanced understanding of biologic and geologic history. In 2014, the CRC again contributed technical assistance to the USGS Central Energy Resources Science Center by slabbing (cutting the core lengthwise) 2,400 feet of important shale cores in order to reveal depositional features vital for USGS oil and natural gas assessments. CRC staff provides collection materials from the Bakken and Niobrara formations to scientists from industry, academia, and government. They cooperated with industry to rescue and curate more than 10,000 feet of core. The CRC staff collaborated with curators from other repositories to discover the best methods to protect and share valuable collections. In 2015, the CRC is meeting the high demand from industry, academia and USGS scientists for access to these collections, and will continue this in 2016.

National Ice Core Laboratory (NICL) – The NICL is the Nation's repository for storing, curating, and studying ice cores recovered from ice sheets, ice caps, and glaciers around the

world, predominately from Antarctica and Greenland. The NICL facility provides the ice core research community with the capability to conduct examinations and measurements on the working scientific collections of ice cores while preserving the integrity of these cores in a safeguarded, temperature-controlled environment for current and future investigations. The NICL is a National Science Foundation (NSF) funded facility operated and maintained by the USGS through an interagency agreement. Research on the ice cores supports the scientific goals of the NSF, Division of Polar Programs in the fields of paleoclimate reconstruction, and atmospheric change and history of the Earth.

Core Science Analytics, Synthesis and Library

(2014 Actual, $22.1 million; 2015 Enacted, $22.0 million; 2016 Request, $23.4 million)

CSASL drives innovation in biodiversity, computational, and data science to accelerate scientific discovery that anticipates and addresses societal challenges. In doing so, the program conducts biological occurrence data acquisition, biological taxonomic analysis and interpretation, computational analytics and synthesis, and provides access to broad collections of scientific information (including USGS publications) in paper and digital forms. CSASL leads the USGS in expanding the capacity for mobilizing data and creating innovative tools and technologies, allowing scientists to collect, access, analyze, integrate, synthesize, and model scientific data.

The USGS Science Strategy emphasizes applied Earth systems information research with a focus on data integration and new methods of investigation. In 2014, CSASL worked closely with other mission areas to leverage expertise and apply it to computing and information needs of science research projects.

In 2014, CSASL developed the USGS Big Earth Data Initiative implementation plan. The plan identifies 60 discrete Earth observing systems from the 2012 Earth Observation Assessment (EOA) that have either direct or associated involvement of Interior bureaus. Datasets for 28 of the 60 Earth observing systems have been registered in bureau and agency catalogs and contribute to Data.gov as part of Open Data Policy response and the public data listing. Data assets from the remainder of the systems will be included in 2015. The Biodiversity Information Serving Our Nation (BISON) and Ocean Biogeographic Information System-USA data integration platforms incorporated data from eight new observation datasets, synthesizing and mobilizing the data for more robust access and analysis—one of the important BEDI treatments for data accessibility and usability.

Scientific inquiries and interpretation require timely access to scientific data. To achieve this, CSASL leads the USGS Community for Data Integration and other communities of practice (e.g., pollinators; invasive species); conducts hands-on training on metadata standards and for common methodologies, tools and applications; and contributes to the development, adoption and implementation of standards.

CSASL will continue its role in science in 2015 and 2016, and will perform research and analysis related to conservation science, vegetation classifications, and taxonomy. CSASL contributed in the development of the National Vegetation Classification Standards, and continues to be the authority on taxonomy in the United States through its oversight of the Integrated Taxonomic Information System.

The USGS Library maintains over 1.8 million physical items, and focus on digitizing important collections while retaining the ability to locate and acquire rare or specialized research products needed by scientists. The Library became part of CSASL in 2014, resulting in efficiencies because of complementary expertise characteristics and functions. In 2015, the Library continues to implement efficiencies and will complete its plan to downsize the Denver and Menlo Park branches. The Library will continue to provide critical research access and discovery assistance to USGS researchers.

CSASL maintains products and capabilities that make national-level data available through interactive systems that facilitate integration, modeling, and visualization of the data. They include—

- **Applied Research Computing (ARC) –** ARC provides High Performance Computing (HPC) capabilities and expertise to USGS scientists for the acceleration and expansion of scientific discovery. Capabilities such as access to USGS specific HPC computing resources, the ability to perform analysis and synthesis utilizing several of the world's fastest supercomputers (e.g., DOE Oak Ridge National Laboratory Titan computer) via interagency agreements, expertise to improve modeling performance via software parallelization methods, and shared commercial license purchases are being made available to USGS scientists, data managers, and collaborators.
- **Biodiversity Information Serving Our Nation (BISON) –** The national integrated resource for U.S. Federal and non-Federal biological occurrence data serves more than 168 million records of species occurrences for every State, county, and congressional district in the United States. BISON serves as the U.S. connection to the Global Biodiversity Information Facility and is the biodiversity hub of the EcoINFORMA informatics capability recommended in the July 2011 report on sustaining environmental capital by the President's Council of Advisors on Science and Technology.
- **Community for Data Integration (CDI) –** The CDI is a collaboration of USGS scientists, data managers, policy experts, and other organizations that promote data management best practices and data integration capabilities. It is an instrumental community of practice for leveraging expertise and resources to test new technologies and institutionalize best practices.
- **Gap Analysis Program (GAP) –** The Gap Analysis Program assesses the status of biodiversity in the United States and provides products from this understanding to better inform resource management decisionmaking at landscape scale. GAP builds and maintains three unique datasets: land cover, land stewardship, and species distributions. GAP conducts a research program to use advanced analytics methods to examine specific taxa, or groups of species of interest to identify the most threatened groups and describe potential conservation priorities. The USGS and other Federal agencies, States, local government, and others use GAP as a source for up-to-date, standardized environmental data that help to determine habitat suitability and guide land purchase decisions.
- **Integrated Taxonomic Information System (ITIS) –** With more than 780,000 scientifically vetted entries, the ITIS is the authoritative source for scientific names of species and higher-level groups of organisms in North America and the world. The ITIS is produced in conjunction with eight other Federal partners that use it as the authority for taxonomic information. Its partnership with the European-based Species 2000 yields the global names standard: Catalogue of Life. ITIS data is used in thousands of databases in industry, academia and government.

- **USGS Library –** Authorized by Congress in 1879, the USGS Library program provides services, collections, and expertise that are essential to fulfilling the U.S. Geological Survey's science mission. The Library is focused on enhancing online resources and services in order to expand access to critical information, consolidate facilities to realize efficiencies, save researchers valuable time, and help further scientific inquiry and discovery.
- **National Fish Habitat Partnership Data System (NFHP-DS) –** The NFHP-DS is a data system that provides Federal and other members of the National Fish Habitat Partnership an integrated data system to upload, interact with, and download data. This reduces data processing workload and increases accessibility needed for national habitat assessments to better inform decisionmakers. The NFHP-DS provides users with geospatial data visualization, downloadable maps, metadata, and map service capabilities. The standard operating procedures developed for data management in the NFHP-DS provide a cornerstone of the USGS response to the U.S. Open Data Policy and the Big Earth Data Initiative.
- **Ocean Biogeographic Information System of the United States (OBIS-USA) –** The OBIS-USA science program synthesizes data on marine biology to better define, understand, and address pressing societal issues that threaten marine ecosystems. The OBIS-USA provides a digital repository of marine biological data following international standards and supporting the U.S. Open Data Policy. The OBIS-USA provides access to more than twenty million records, and is the official hub for the United Nations' Education, Science and Cultural Organization's Intergovernmental Oceanographic Commission. The OBIS-USA serves as the synthesized data system for the biological data of the Integrated Ocean Observing System, the Bureau of Ocean Energy Management, and the newly formed Marine Biodiversity Observing Network.
- **ScienceBase –** ScienceBase is a data and information management capability that enables data upload, documentation, sharing, and dynamic data services through standards-compliant methods and technological components to provide a foundation for data stewardship, government open data, and scientific discovery.
- **Science Data Management –** This component provides bureauwide leadership in establishing and implementing science data-management practices. It provides access to standards, workflows, training, and tools to help ensure Federal data is properly maintained, described, preserved, and made accessible.

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Activity: Core Science Systems

Subactivity: National Cooperative Geologic Mapping

2014 Actual: 24.4 million (112 FTE)
2015 Enacted: 24.4 million (112 FTE)
2016 Request: 25.3 million (114 FTE)

Overview

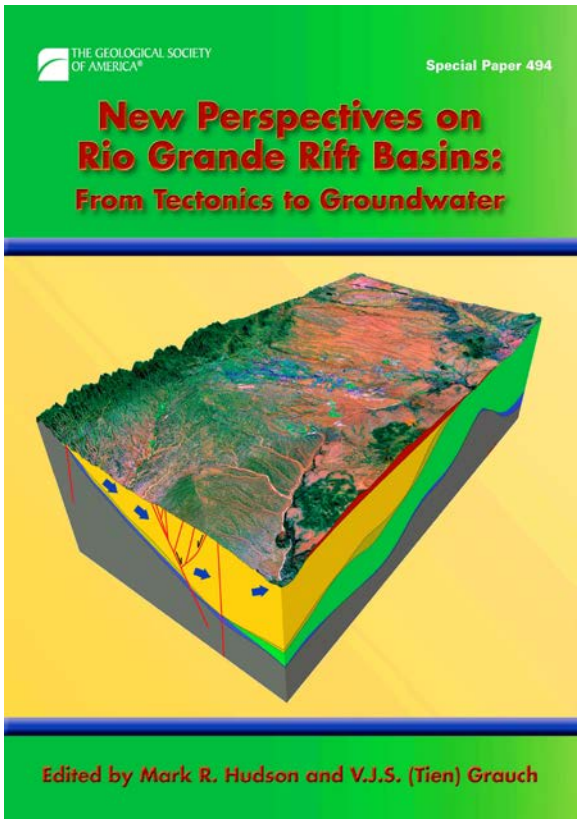
In a time when so many solutions to the Nation's most pressing problems lie in the ground beneath our feet, the National Cooperative Geologic Mapping Program (NCGMP) advances the understanding of the nature of the materials—rocks, energy resources, water—and processes such as characterization, containment, and flow. This nationwide program of geologic research produces about 100 peer-reviewed journal articles annually on surficial and bedrock geology, mapping, and multidimensional models that provide fundamental research and data that underpin all of the themes of the USGS Science Strategy. These primary findings and data are applied in natural hazards mitigation, water resources delineation, energy and minerals exploration, climate change studies, and ecosystem and environmental health analysis and are readily accessible through the National Geologic Mapping Database.

In 2013, the NCGMP marked the 21st anniversary of the National Geologic Mapping Act of 1992, by establishing an annual award for the Best Student Geologic Map at the Geological Society of America meeting. This award has now become a tradition in training the next generation of geologic mappers. Over its history, the program has leveraged over $113 million in Federal funding matched by the State geological surveys to collaboratively

National Cooperative Geologic Mapping

"A foundational science program: determining the geologic framework of areas determined to be vital to the economic, social, or scientific welfare of the Nation."

National Geologic Mapping Act 2009 (P.L. 111-11)

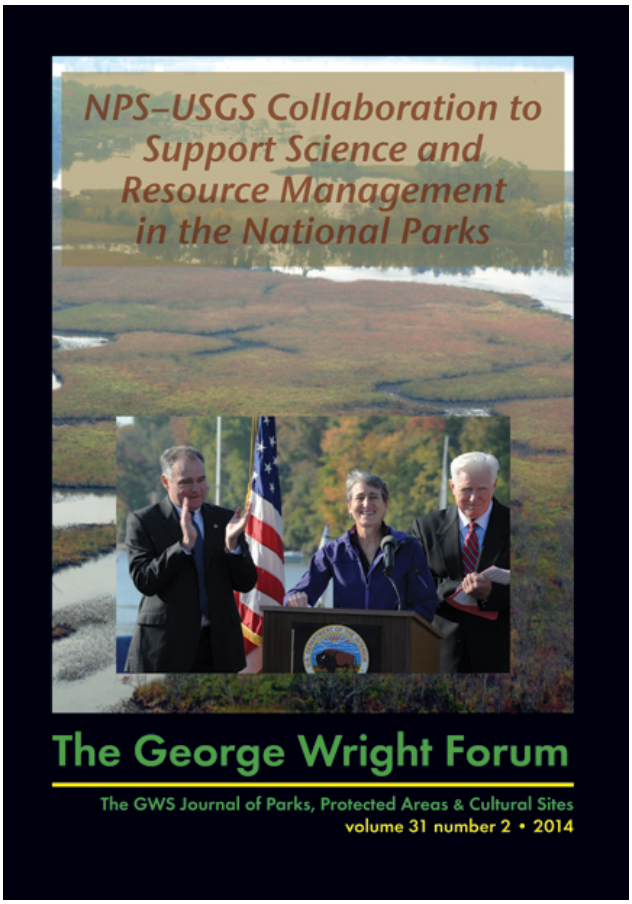


The 18 journal articles published by USGS scientists and their partners in other Federal and State agencies, as well as academia, tell the complex geologic history of the Rio Grande rift valley and the sedimentary basins that contain the aquifers that supply water to Albuquerque, Santa Fe, and other communities. This research provides the landscape-level understanding for decisionmakers in New Mexico and southern Colorado, especially about water issues.

produce modern geologic maps for the Nation and $8.7 million matched by universities to train the next generation of geologic mappers—more than 1,100 college geoscience students to date.

Geologic maps and frameworks define the subsurface shape of aquifers, how much water can be stored in them, and parameters for water movement through the ground. Geologic mapping products also provide critical information for predicting and mitigating natural hazards, such as landslides, earthquakes, and volcanoes. In 2014, geologic maps were critical tools used in emergency response situations such as major landslides that had human casualties in Washington State and western Colorado.

The NCGMP supports a major Federal geologic mapping partnership between the USGS and the National Park Service (NPS). In the past 15 years, the NCGMP has helped the NPS to inventory the geologic resources of more than 200 parks and to create digital geologic maps in many of them. Park managers require these products for making effective landscape-level decisions.



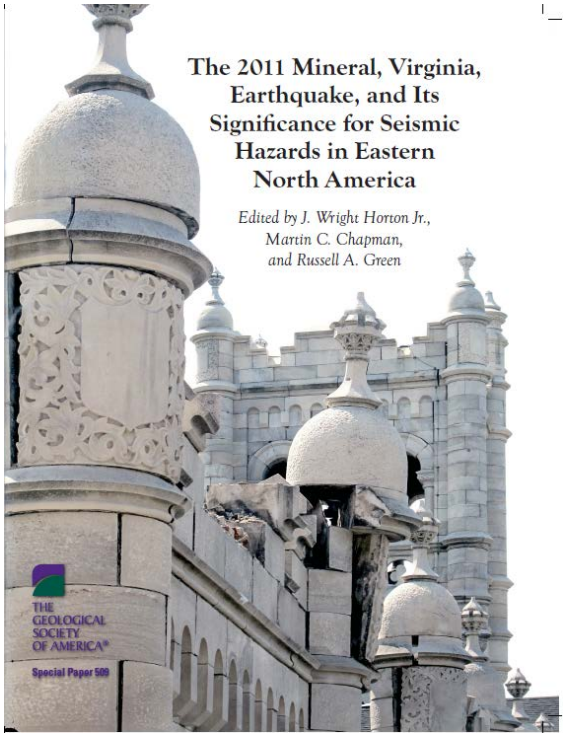
A hallmark of the NCGMP, the National Geologic Map Database, is a major collaborative effort with the Association of American State Geologists (AASG). This national database provides rapid access for the general public, scientists, and decisionmakers to well-documented and standardized Federal and State geoscience information that can be used to support research, understanding, and decisions on a number of societal needs. Of note in 2014, a newly redesigned Map Viewer interface elicited universal praise. Through annual workshops, this project leads national-level information exchanges and the development of more efficient methods for digital mapping, cartography, geographic information system analysis, and information management.

The NCGMP works in close collaboration with State geological surveys, such as with the Great Lakes Geologic Mapping Coalition. This coalition is a Federal-State partnership created to produce urgent, detailed, three-dimensional surficial-materials maps that provide a foundation for making sound economic and environmental decisions related to ground water resources, land, and other natural resources of the Great Lakes.

In 2015, Congress appropriated $2.0 million for hydraulic fracturing studies. The NCGMP is developing three-dimensional geologic maps to better understand rock structures that form the basis to characterize the hydro-geologic framework used to understand impacts.

Program Performance

The USGS Education Mapping Program (EDMAP) program is highly regarded throughout the Federal Government and academic communities as being one of the most effective Earth science education programs that focuses on geosciences workforce training and as a pipeline for geologic mapping professions. In satisfaction surveys of the student participants, respondents report that they have gained valuable research and mapping skills that enable them to be highly competitive in the geosciences job market upon graduation. In addition, many EDMAP alumni have pursued academic careers and are in turn educating a new generation of Earth scientists. For more information, go to *http://www.usgs.gov/core_science_systems/access/fall_2012/article-1.html*



Third Annual National Geologic Map Day – During the American Geosciences Institute (AGI)'s Earth Science Week, the USGS and the AASG partnered with the AGI to celebrate the third annual Geologic Map Day on October 17, 2014. The event concluded Earth Science Week, which boasts the participation of roughly 49 million people annually. Focused primarily on K-12 educators, Geologic Map Day is designed to inform the public while engaging students across the Nation, and to advance STEM (Science, Technology, Engineering, and Mathematics) education efforts. Teachers were provided with wide-ranging materials related to geologic mapping, reinforced by classroom visits from local scientists with geologic mapping expertise, knowledge, and field experience.

FEDMAP – Federal Geologic Mapping Science and Applications

(2014 Actual, $17.0 million; 2015 Enacted, $17.0 million; 2016 Request, $17.1 million)

The FEDMAP component of the NCGMP supports about 25 regional geologic mapping and synthesis projects that cross jurisdictional-boundaries. New and ongoing geologic mapping work plans are evaluated annually by a FEDMAP Review Panel, which includes representatives from State geological surveys, the NPS, and USGS researchers that have diverse scientific backgrounds.

Examples of NCGMP interdisciplinary geologic mapping 2014 accomplishments that contribute to answering a breadth of the Nation's natural resource issues include—

- Groundwater availability, movement, and contamination across the United States, such as in California, New Mexico, Colorado, the mid-Atlantic Coastal Plain, and New England.
- Earthquake hazards mitigation in the Seattle-Portland urban corridor, California, the Central United States, and Virginia; landslide hazards in Washington State, Colorado, New York, and California; and sinkhole hazards in numerous Eastern States.
- Ecosystem health in the Platte River Basin, in national parks, the Appalachian Blue Ridge Mountains, on Native lands in cooperation with tribal nations, and along the U.S.-Mexico border.
- Climate change understanding in the mid-Atlantic, California, and the Greater Platte River Basin, and Mojave Desert.
- Energy and mineral resource occurrence in Nevada, Arizona, Colorado, Pennsylvania, and New York; some of this work will provide subsurface framework in areas under development for hydraulic fracturing.
- In 2014, the National Karst Map was released and is useful in identifying areas with potential for sinkholes. In 2015, the FEDMAP program will publish a new map of the greater Portland, Oregon area, which highlights major earthquake faults landslides providing another valuable tool for hazard and emergency response.
- Publication in the journal Geospheres of *Geologic history of Siletzia, a large igneous province in the Oregon and Washington Coast Range: Correlation to the geomagnetic polarity time scale and implications for a long-lived Yellowstone hotspot* has significantly revised the tectonic history of the Pacific Northwest and interestingly links extensive volcanism in the Columbia River Gorge with the hotspot that presently underlies Yellowstone National Park.
- In early celebration of the National Park Service 100th anniversary, two important articles were published in The George Wright Society Forum: the first is entitled *Interagency Partnership to Assess and Restore a Degrade Urban Riverine Webland: Dyke Marsh Wildlife Preserve, Virginia,* and the second is titled *USGS Geologic Mapping and karst Research in Ozark National Scenic Riverways, Missouri, USA.*
- In 2014, the Online First version of the Geological Society of America Special Paper: *The 2011 Mineral, Virginia, Earthquake and Its Significance for Seismic Hazards in the Eastern United States* was released This volume contains 23 articles written by USGS scientists and colleagues in State geologic surveys and academia. The research gleaned since the earthquake that damaged the Washington Monument and other significant structures in the DC-VA area is revising our understanding of seismic risk in the Eastern United States.

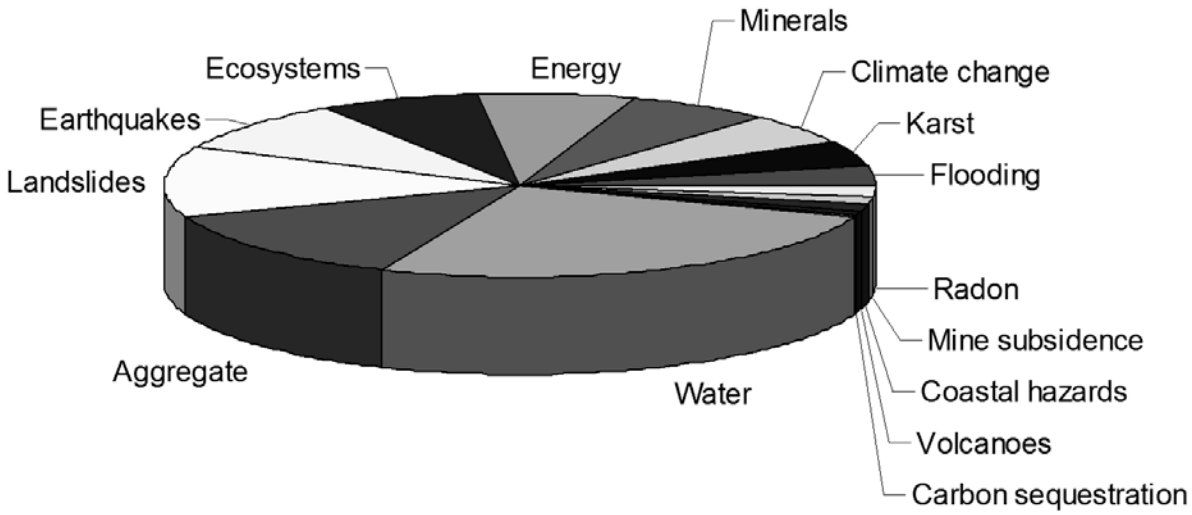
STATEMAP – Serving State Priorities for National Needs

(2014 Actual, $6.9 million; 2015 Enacted, $6.9 million; 2016 Request, $6.9 million)

The STATEMAP component of the NCGMP currently supports geologic mapping studies conducted by 44 State geological surveys through a competitive cooperative agreement program that matches every

Federal dollar with a State dollar. Since STATEMAP's inception in 1993, 48 States have matched more than $113 million. In each State, geologic mapping priorities are determined with the help of State Mapping Advisory Committees that include representatives from all levels of government, the private sector, academia, and industry. Currently, more than 500 individuals offer their time on these committees to prioritize geologic mapping needs. This group acts as "grass roots" allowing the program to stay in touch with citizens' greatest needs. States propose mapping projects based on their highest priority societal, economic, and scientific issues.

Societal Applications of Federal and State Geologic Mapping



Many STATEMAP geologic mapping projects provide vital information needed by States and industry. Program outcomes from geologic mapping for the 2014 proposal cycle include mapping that provides information primarily for groundwater quantity and quality projects across the United States. For example, the Washington State Geological Survey mapped the Lake Chaplain 7.5 minute quadrangle that was used by the King County Water and Land Resources Division for river and floodplain management, groundwater protection and infrastructure planning, and to identify landslide hazard areas. STATEMAP geologic maps have the potential to aid in understanding hydraulic fracturing in the development of unconventional gas production.

EDMAP – Training the Next Generation of Geoscientists

(2014 Actual, $0.5 million; 2015 Enacted, $0.5 million; 2016 Request, $0.5 million)

The EDMAP component of the NCGMP supports the training of a new generation of geoscientists in universities and colleges through a competitive matching-fund cooperative agreement program. Through the EDMAP program, students learn the fundamental principles of geologic mapping and field techniques. Since EDMAP's inception in 1996, more than $8.7 million from the NCGMP has supported geologic mapping efforts of more than 1,100 students working with more than 230 professors at 157 universities in 45 States, the District of Columbia, and Puerto Rico. Sponsoring universities match, dollar-for-dollar, the Federal EDMAP funding they are awarded. This commitment to STEM education,

engaging young scientists in important societal problems and into the field, is one of the program's highest priorities. This year marked the 2nd annual Best Student Geologic Map Competition co-hosted by the Geological Society of American and sponsored by partner organizations. The competition provides EdMap students and others a venue to showcase their mapping projects to a wide audience of scientists, professionals, and their peers.

Winners of the 2014 Best Student Geologic Map Competition—Vancouver GSA Meeting

Activity: Core Science Systems

Subactivity: National Geospatial Program

2014 Actual: 60.1 million (302 FTE)
2015 Enacted: 58.5 million (260 FTE)
2016 Request: 75.7 million (266 FTE)

Overview

The National Geospatial Program (NGP) organizes, updates, and publishes the geospatial baseline of the Nation's topography, natural landscape and built environment through *The National Map*; and conducts geospatial research to discover new approaches for updating and using geospatial data and for reducing costs of these activities. The National Atlas of the United States has transitioned into The National Map as its small-scale depiction to provide an integrated single source for geospatial and cartographic information. Users throughout the Federal Government, including those in Interior, the Department[s] of Agriculture (USDA), Commerce, and Defense; the Environmental Protection Agency (EPA), the Federal Emergency Management Agency, National Guard Bureau; and States, tribes, the private sector, and other organizations use NGP geospatial data and Web services to support their decisionmaking and operational activities. The NGP focuses its efforts in the areas of water resource and flood risk management, geologic mapping and hazards, and natural resource management. NGP-sponsored cooperative data acquisition projects reduce duplication of expenditures among Federal agencies and with State and local governments, and result in millions of dollars in contracts for America's geospatial industry. The NGP supports the Interior's responsibilities for national geospatial coordination, and carries out the USGS's governmentwide leadership responsibilities for elevation, hydrography and watershed boundaries, and geographic names.

The Federal Geographic Data Committee Office of the Secretariat (FGDC OS) coordinates geospatial activities across Federal agencies and with non-Federal organizations as required by the Office of Management and Budget (OMB) Circular A-16 and Executive Order 12906. The FGDC OS provides support for key Federal geospatial initiatives and priorities, including the Geospatial Platform, the National Spatial Data Infrastructure (NSDI) Strategic Plan, and the OMB Circular A-16 Supplemental Guidance and its associated National Geospatial Data Asset Management Plan. The Geospatial Platform directly supports Interior's Strategic Plan goal to provide shared landscape-level management and planning tools, and supports other Federal mission areas as a shared service and primary community collaboration tool. These activities support and enhance information availability for decisionmaking and science, increase information delivery efficiencies, and minimizes duplication of Federal geospatial-data assets through shared services that leverage economies of scale.

Program Performance

3D Elevation Program (3DEP) USGS Circular 1399, "The 3D Elevation Program Initiative – A Call for Action" provides a plan to systematically collect improved, high resolution elevation data for the 50 States, District of Columbia, Puerto Rico, and the U.S. territories over an eight-year period. The 3DEP uses advanced laser technology, known as lidar (light detection and ranging), to build the most detailed and complete elevation maps ever produced on a nationwide scale. The plan was crafted based on extensive stakeholder input from a variety of organizations, including the interagency 3DEP Executive Forum that conducts quarterly meetings of executives from 12 Federal agencies and the interagency Digital Elevation Program (NDEP), that provides operational coordination for 3DEP. States and the private sector are avid supporters of the plan.

In January 2015, the NGP rolled out the first phase of new 3DEP products and services.

Remapping Alaska – The NGP is working with the State of Alaska and Federal partners to replace the more than half-century-old topographic maps for Alaska. The program is using new and more accurate geospatial data to improve aviation safety, understand and mitigate the effects of coastal erosion and storm surges, provide infrastructure for Arctic shipping and resource extraction, and protect biodiversity and habitats. The NGP and its partners have embarked on a five-year plan (2013-2018) to acquire data to remap the State, with an emphasis on replacing elevation data for the State using ifsar (interferometric synthetic aperture radar) technology. Unlike conventional technology, ifsar allows for elevation data collection in challenging conditions including cloud cover, which is common in Alaska. The Alaska Mapping initiative is a combined Federal, State, local and tribal program to support and improve maps and digital map data for Alaska, bringing Alaska topographic map and digital map data quality in line with the rest of the United States.

In 2014, statewide ifsar coverage improved from 43.5 percent to 50.6 percent. The cumulative number of updated US Topos in Alaska at the end of 2014 was 1,121.

Geospatial Platform – On behalf of the FGDC Chair (Interior) and Vice-Chair (OMB), the 32 Federal member agencies, and the Geospatial Platform Managing Partner (Interior, Office of the Chief Information Officer), the FGDC OS advocates the implementation of the Geospatial Platform to support problem solving and policy formulation for complex issues facing the Nation. The Geospatial Platform provides a suite of well-managed, highly available, and trusted geospatial data, services, and applications for use by Federal agencies and their State, local, tribal, and regional partners and includes the release of collaborative online communities for shared geospatial data investment planning and service acquisition to reduce duplicative investment and increase return on investment.

In 2014, the Geospatial Platform released collaboration communities supporting key national priority areas including homeland and human security and climate resources. Sixteen communities focused on improving the management, transparency, and availability of National Geospatial Data Assets as directed by OMB Circular A-16 policy.

User Engagement

(2014 Actual, $9.8 million; 2015 Enacted, $9.0 million; 2016 Request, $9.1 million)

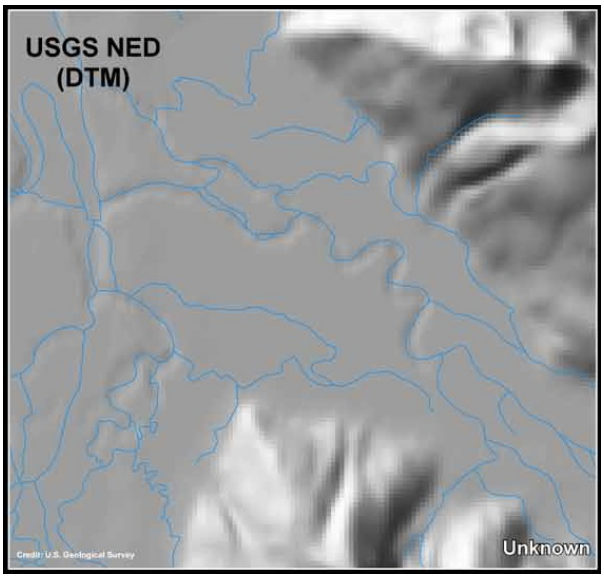
The User Engagement component works within the USGS and with States and other Federal agencies to optimize how the USGS develops The National Map to best meet user needs. The component performs targeted outreach and provides technical and programmatic support to demonstrate the applicability of NGP products and services in meeting users' geospatial data requirements. Communities of Use (Geologic Mapping and Hazards, Natural Resources Conservation, and Water) are engaged to determine and prioritize user requirements of USGS scientists, Interior and other Federal resource managers, and State and local decisionmakers. User Engagement includes Federal and National Map Liaison activities to develop and maintain relationships with users and sources of authoritative data. Through these efforts, the USGS ensures program capabilities to meet current and future requirements and mission needs for 3D elevation and hydrography data and applications across the broadest possible spectrum of users. The component supports the Alaska Mapping Executive Committee, coordinates NGP efforts to modernize mapping including over the State of Alaska, and provides USGS support for geospatial needs related to natural hazards response and emergency responders. Starting in 2015, it supports the USGS Geospatial Information Response Team to acquire and provide access to satellite and aerial imagery and maps to support response to domestic natural hazard events including tornadoes, snowstorms, wildland fires, and debris flows.

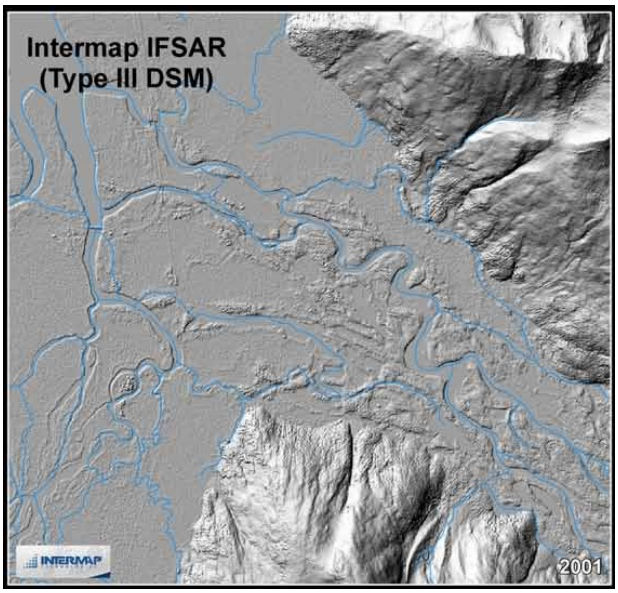
Topographic Data Services

(2014 Actual, $16.0 million; 2015 Enacted, $20.9 million; 2016 Request, $25.6 million)

The Topographic Data Services component funds the 3D Elevation Program (3DEP), National Hydrography Dataset (NHD), and a portion of the Watershed Boundaries Dataset (WBD) in collaboration with the USGS Water Mission Area. Topographic Data Services develops and manages the strategy for products and services development, and data acquisition and stewardship for NGP's priority data themes of elevation and hydrography. In 2014, the NGP issued a Broad Agency Announcement (BAA) that provides detailed information on how stakeholders can partner with the USGS and other Federal agencies to acquire high-quality 3D data. (See *http://nationalmap.gov/3dep/BAAReferenceMaterials.html*) The component defines and implements annual and multi-year 3D elevation data acquisition plans including project selection and collaborative partnerships. It also defines and supports the quality assurance, processing, and management of a very high volume of elevation data on a national level. The NHD and WBD are maintained through interagency stewardship agreements. Because of its reliance on partnerships, Topographic Data Services provides executive support to several user groups including the 3DEP Executive Committee and the Advisory Committee on Water Information and National Hydrography Dataset Management Team. It co-leads, with the National Oceanic and Atmospheric Administration (NOAA) and U.S. Fish and Wildlife Service, OMB Circular A-16 theme and dataset management leads for elevation and inland waters.

Comparison of older USGS National Elevation Dataset (NED) with newer ifsar elevation data:





Elevation: In 2014, the NGP developed 3DEP to acquire lidar data coverage nationally and ifsar data for Alaska; this work will continue in 2015, and is proposed to expand in 2016. Key stakeholder groups, including the 3DEP Executive Forum, the multi-agency NDEP and others, reviewed and provided input to the 2014 3DEP implementation plan. Consolidation and modernization of operations to support streamlined quality assurance, processing, and data management are underway and a unified data acquisition plan was published in September 2014, under the BAA. New 3D products and services will be made available in 2015. The program will continue to acquire, process, manage, and deliver higher

quality elevation data over large project areas to address a greater number of user needs and to meet national 3DEP goals. The NGP collaborates with NOAA on the U.S. Interagency Elevation Inventory to document publicly available elevation data on an annual basis.

Hydrography and Watershed Boundaries: The NGP assures the quality and integrates detailed hydrography data updates submitted by Federal and State data maintenance stewards. In 2014, the NGP began a new approach to update surface water data for Alaska. In 2014, NGP began developing a high-resolution (1:24,000 scale) version of NHDplus that (1) incorporates the functionality of multiple existing datasets; (2) provides a method to transfer previously captured data so that all are available for analysis; and (3) improves the scale of the data to support more detailed analysis than is available in version 2 of the medium-resolution (1:100,000 scale) NHDplus. This supports the National Water Census and hydrologic modeling activities by organizing hydrologic observations with the Nation's river network and watersheds, which is an initial step in delivering the Open Water Data Initiative. In 2015, the NGP will complete a Water Data Requirements and Benefits Study to document Federal, State, and private sector user needs and return on investment for water data, to help define the next generation of hydrography data.

3D Nation: Building a modern elevation foundation nationwide for stronger, more resilient communities and U.S. economy: The 3D Elevation Program is one component of an interagency **3D Nation** partnership that will ensure access to an accurate, routinely updated, continuous elevation surface from the land to the depths of our waters. 3D Nation coordinates and unifies the goals of the USGS 3D Elevation Program (3DEP), NOAA's GRAV-D program, and the coastal topographic and bathymetric mapping activities of NOAA, USGS, FEMA, USACE and the States. In some instances, old data will be replaced with data that are accurate to within centimeters of their real-world positions. 3D Nation will provide an authoritative national geospatial foundation to support mapping needs for commerce, agriculture, land and sea navigation, resource management, climate change, hazards response, and a host of other activities. It will result in economic and job growth and lead to private sector innovations in each of these business areas.

In 2014, the NGP matched $7.3 million of program funds with $46.5 million of cooperator resources to acquire $53.8 million of elevation, hydrography, and imagery data for The National Map. Through partnerships coordinated in the Alaska Mapping Executive Committee, the ifsar data coverage for the State was 44 percent (on a path to achieve 100 percent coverage by 2017). Using Hurricane Sandy Supplemental funds, the NGP matched $4.5 million with $1.0 million contributed funds from States to acquire $5.6 million worth of lidar data over the east coast impact area. In 2015, the NGP will increase the amount of 3D elevation and hydrography data acquired, processed, and ingested into The National Map by ending lower priority activities like the National Atlas, Urban Areas orthoimagery data acquisition, and land cover.

Cartographic Data Services

(2014 Actual, $25.5 million; 2015 Enacted, $19.7 million; 2016 Request, $20.7 million)

The Cartographic Data Services component guides the planning and use of technology to create and deliver modern topographic maps, deliver National Map products and services, develop and maintain geospatial data to support mapping and geospatial analysis at local, regional, and national scales, and apply The National Map, geographic names, historic topographic scanned maps, and cartographic base maps to support Web mapping applications within the bureau, Interior, other Federal agencies, and State/local/private entities. Efforts ensure availability of nationally consistent, modernized, scalable, and

integrated base geospatial data and technology for use by USGS scientists and researchers as well as external partners and customers. Cartographic Data Services activities include data processing, decision-support systems, and cloud-based storage and delivery services for geospatial information.

The National Map includes national databases of geospatial imagery, transportation, structures, and boundaries, although the USGS relies on partners to acquire and be stewards of these data. The component also funds cartographic products derived from National Map data and other associated geospatial services generated from the databases, such as the US Topo digital topographic maps and National Map visualization services.

Geographic Names: The NGP maintains geographic names data and staffs the Board on Geographic Names (BGN), authorized by P.L. 80-242. In 2014, NGP continued to house and provide access to all of the Geographic Names information that has been collected over the years. Starting in 2015, consistent updates will be provided only to the base cartographic features necessary to support the USGS topographic mapping mission.

US Topo: To keep pace with an increasing demand for updated map products and data and technological advances, the USGS continues to revise each US Topo map every three years (70 maps each day) and to post new digital topographic maps for download. The quadrangles of US Topo maps are created from geographic datasets in The National Map and allow the user to select among data layers to be displayed; a technology advancement not available on older paper-based topographic maps. The new US Topo maps provide other modern technological advantages that support wider and faster public distribution, and on-screen geographic analysis tools for users. US Topo maps have a new crisper and cleaner design that enhances the readability of maps when viewed online and printed.

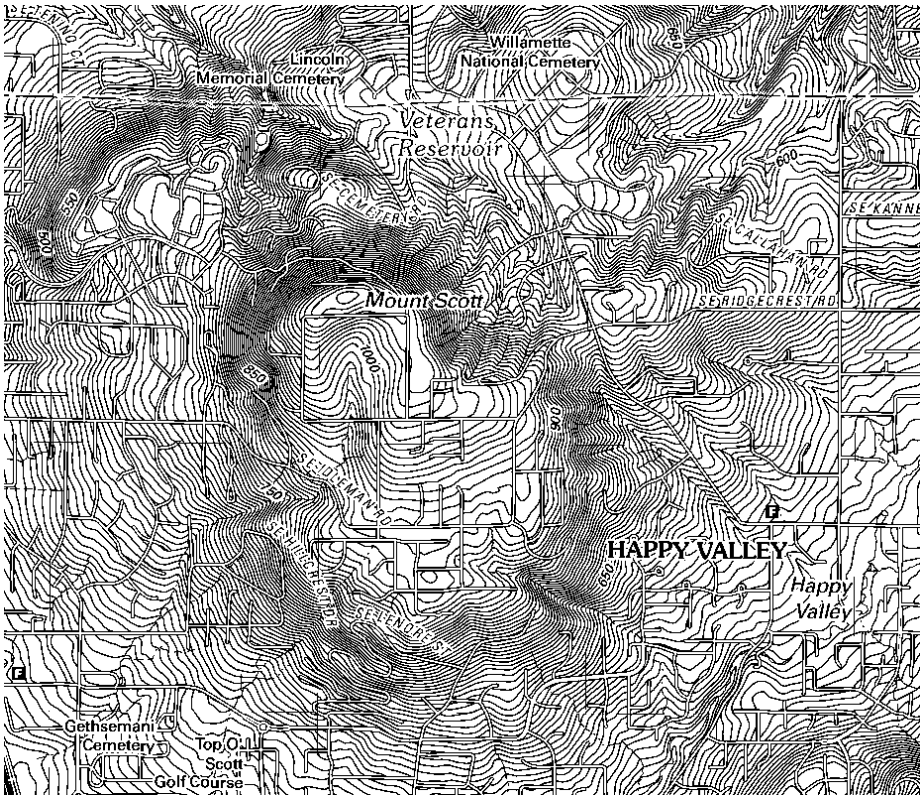


Figure 1. Portion of US Topo design from 2011 (Gladstone, OR)

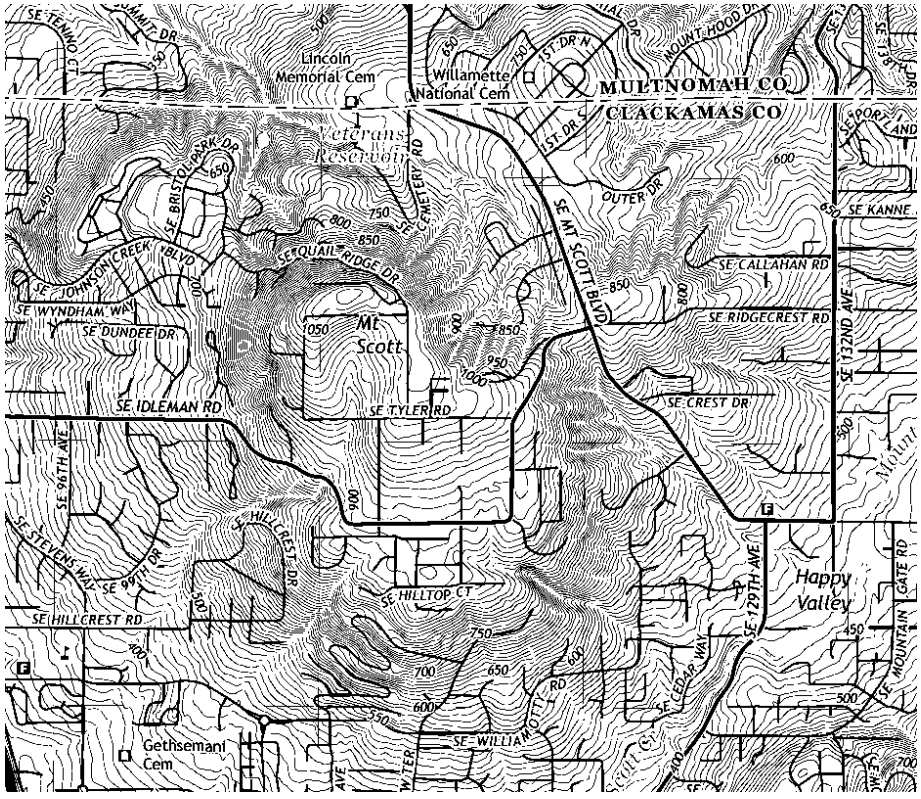


Figure 2. Portion US Topo from 2014 using the new design (Gladstone, OR)

In 2014, the NGP completed the second year of a three-year revision cycle for remapping the conterminous United States for the 2013-2015 cycle. The program also mapped Hawaii, Puerto Rico, and the Virgin Islands, and began mapping Alaska. Completion of the Alaska Mapping Initiative is scheduled for 2018. US Topo products are freely downloadable from The National Map Viewer and Download Platform as well as the Geospatial Platform. Through December 2014, more than 6 million US Topo Products had been downloaded from USGS sites with a daily average of 6,200 in 2014.

Historical Topographic Map Collection (HTMC): In conjunction with the US Topos, the USGS released more than 188,000 online high-resolution scans of historical topographic maps of the United States dating back to 1884 (founding of the USGS mapping program). Until 2013, the historic maps were only available in a paper format and by citizens and researchers visiting the Library of Congress and other depository libraries in person. The HTMC has accurately cataloged and created metadata to accompany the high-resolution, georeferenced digital files that make available the Nation's legacy of printed topographic maps.

The NGP is unique in providing acquisition and distribution of satellite and aerial imagery to emergency responders. In 2014, the NGP supported response efforts for 35 domestic emergency events, including tornadoes, snowstorms, wildland fires, explosions, and debris flows.

The NGP publishes its digital geospatial data and maps through data downloads, Web map services, and a robust National Map viewer. In 2014, the program made its 178,753 historical topographic maps available to the public through the Geospatial Platform and Data.gov. During 2014, users downloaded 2.5 million US Topo maps and 2.8 million historical topographic maps.

Users have noticed the NGP's continued improvements to data access through Web services. The availability of National Map visualization services encouraged use by mobile application developers worldwide that specialize in geospatial data. Several developers adopted the services for use immediately and National Map data are now available in several recreational use mobile applications supporting hiking, biking, and touring that run on cell phones and tablets. Mobile applications that use The National Map data and services include Oruxmaps (*http://www.oruxmaps.com/index_en.html*), AlpineQuest (*http://alpinequest.psyberia.net/*) and Galileo (*https://galileo-app.com/*). The usage statistics for National Map basemaps for 2013 showed a significant jump in data access with mobile access accounting for at least 50 percent of the traffic.

Geospatial Research

(2014 Actual, $5.0 million; 2015 Enacted, $5.1 million; 2016 Request, $5.3 million)

The Geospatial Research component funds applied research that improves the efficiency and effectiveness of The National Map and its operations, products, and services, and contributes to the Nation's understanding of geospatial science. Components of a digital topographic map design and map generalization research project have been completed, and the NGP is using the results to improve the design of the US Topo maps and to take advantage of detailed hydrography data for maps at regional and national scales.

In 2015, the program will continue to expand its work in geospatial semantics and ontology. The goal of this internationally recognized work is to enable discovery and linkages to The National Map data using natural language versus technical GIS-specific terminology. Using USGS staff in conjunction with academic research grants, the NGP will research access to legacy geospatial data and enhanced elevation data to support integration with other USGS science data and modeling. It will identify relations between map scale and geomorphological and other characteristics of map features to automate generalization (zooming in and out while still maintaining a legible image) and determine the effects of high-resolution elevation and hydrographic data on science models. The researchers will integrate data from The National Map with selected USGS science datasets to support visualization, analysis, modeling, and decisionmaking efforts of USGS, other government agencies, and the public in addition to evaluating how geospatial data can be used to help restore supply chains after a natural disaster. Finally, USGS researchers will explore high performance computing and Cyber GIS to support processing of the massive amounts of lidar and derivative data and products that 3DEP creates.

Federal Geographic Data Committee – Office of the Secretariat

(2014 Actual, $3.8 million; 2015 Enacted, $3.8 million; 2016 Request, $15.0 million)

The FGDC is an interagency committee that coordinates the collection, use, and dissemination of geospatial data and information to develop the National Spatial Data Infrastructure (NSDI). It promulgates standards, system interoperability, geospatial shared services, and best business practices, policies, technology, and partnerships. The Secretary of the Interior chairs the FGDC, and the Deputy Director for Management, OMB, serves as the Vice-Chair. The FGDC OS provides executive, administrative, and technical support to the FGDC.

In 2014, the FGDC released enhancements to the Geospatial Platform, an Internet-based capability providing shared and trusted geospatial data, services, and applications for use by government agencies, their partners and the public. Enhancements included identity and access management controls and self-service community management tools that allow agencies to control and directly update their community's content, reducing update time and increasing agency access. As an identified tool supporting the Secretary of the Interior's Landscape Level of Understanding goal, the FGDC through the Geospatial Platform, released 17 cross-agency collaboration communities and five tools that can be used to support landscape-level capabilities and mitigation actions. The FGDC worked with partner agencies to release collaboration communities supporting key national priority areas including the Homeland Security Geospatial Concept of Operations, World-Wide Human Geography, and Climate resources. These communities leverage the Geospatial Platform's shared data, services, and tools to provide information sharing and best-practices, and to support solution development and decisionmaking. Sixteen communities supporting the development of National Geospatial Data Assets were launched to increase the access, use, accountability and management of key Federal geospatial data assets, and provide them as standards-based Web services to promote reuse. The FGDC completed, endorsed, and began implementation of the National Spatial Data Infrastructure (NSDI) Strategic Plan 2014 – 2016, and the National Geospatial Data Asset Management Plan (NGDAMP). These plans were widely vetted, reviewed, and endorsed by Federal agencies and non-Federal partners to provide direction for the Federal Government's role in implementing the NSDI and ensuring increased efficiency, management, and availability of federally funded geospatial data. The FGDC continued to execute the geospatial cloud

computing testbed, collaboratively developing cloud-based, geospatial-computing environments that are preapproved for deployment across agencies, reducing individual deployment costs. The Secretariat supported all FGDC activities, including the FGDC committees, the National Geospatial Advisory Committee, development of geospatial standards, establishment of the Geospatial Platform as a Shared Service, and the close out of the Cooperative Agreements Program (CAP).

In 2015, the FGDC OS continues to support FGDC activities focusing support on development and expansion of the operational phase and core capabilities of the Geospatial Platform, working with numerous agencies to establish new collaborative communities and new shared tools, implementing NSDI Strategic Plan actions, and working with FGDC agencies to further develop their NGDAMP strategy and implement reporting tools to increase information access and accountability. The implementation of the Geospatial Platform's shared, cloud-based, data hosting environment will begin, leveraging the best practices from the geospatial cloud computing testbed. In 2016, the Geospatial Platform will begin implementing services supporting its role in the Federal reference architecture as a technology and collaboration environment for unclassified geospatial information sharing and continue to mature its shared services with guidance from the *Geospatial Platform Business Plan* and Geospatial Platform Oversight Body. The Secretariat will continue to support the FGDC agencies in implementing the actions of the NSDI Strategic Plan and the National Geospatial Data Asset Management Plan and will initiate the proposed Community Resilience Toolkit.

Science Support

Activity: Science Support

		2014 Actual	2015 Enacted	2016 Fixed Costs and Related Changes (+/-)*	2016 Internal Transfer	2016 Program Changes	2016 Budget Request	Change from 2015 (+/-)
Administration and Management ($000)		86,985	84,192	2,210	0	4,197	90,599	6,407
	FTE	425	411	0	0	17	428	17
Information Services ($000)		23,719	21,419	190	0	620	22,229	810
	FTE	68	66	0	0	2	68	2
Total Requirements ($000)		**110,704**	**105,611**	**2,400**	**0**	**4,817**	**112,828**	**7,217**
Total FTE		**493**	**477**	**0**	**0**	**19**	**496**	**19**

**Fixed Costs are $2,263 and Seasonal Federal Health Benefits are $137*

Summary of Program Changes

Request Component	($000)	FTE	Page
Administration and Management	**4,197**	**17**	
DOI Science Coordination	200	1	C-82
Mendenhall Program Postdocs	500	1	C-83
Outreach to Underserved Communities	200	0	C-84
Support Science Mission, Infrastructure Capacity to Support Science	1,997	14	C-78
Tribal Science Coordination	300	0	C-82
Youth & Education in Science	1,000	1	C-84
Information Services	**620**	**2**	
Support Science Mission, Infrastructure Capacity to Support Science	620	2	C-78
Total Program Change	**4,817**	**19**	

Justification of Program Changes

The 2016 budget request for Science Support is $112,828,000 and 496 FTE, a net change of +$7,217,000 and +19 FTE from the 2015 Enacted Budget. For more information on the Science Support Mission Area changes, please see Section C, Program Changes as indicated in the table.

Activity Summary

The Science Support Activity provides the functions that make it possible to conduct USGS science; it is the framework for the USGS. This Activity provides business and information systems including: acquisitions and grants, finances, internal controls, communications, budget, monitoring and evaluation of science quality and integrity, education, technology services and human capital, each of which are crucial to the functioning of good science. Science Support includes the executive leadership and management that provide guidance, direction and oversight of all USGS science activities.

For 2016, the Science Support Activity would use additional funding to retain proportionality with the USGS science mission to provide the essential foundation and structure to conduct world-class science and allow implementation of support activities that would advance the USGS science mission. The essential support functions and services provided by the Administration and Management and Information

Services subactivities form the foundation for the USGS science mission. The breadth of responsibilities funded include purchasing scientific equipment and field supplies, developing science agreements with partners, contracting for support scientists and researchers, safety training, hazardous waste management, strategic planning, succession planning, hiring, staffing, information technology, and employee development and training. Youth and Education would contribute to national Science, Technology, Engineering and Mathematics goals for future workforce capabilities by providing work experiences to students and the opportunity to participate in science projects contributing to improving their world. Science Coordination will contribute to building and maintaining networks of scientists and increased collaboration opportunities.

The Science Support Activity is comprised of two subactivities: Administration and Management, and Information Services.

Activity: Science Support
Subactivity: Administration and Management

2014 Actual: $87.0 million (425 FTE)
2015 Enacted: $84.2 million (411 FTE)
2016 Request: $90.6 million (428 FTE)

Overview

The Administration and Management subactivity provides bureauwide leadership and direction; establishes organizational vision, mission, goals and scientific priorities; develops and enforces standards for scientific rigor and integrity; plans, obtains and manages necessary resources including people, budget authority, facilities and equipment; provides resource management systems; implements statutory and regulatory requirements and monitors and enforces compliance; and communicates the USGS mission and science to Congress and the public. Administration and Management is comprised of the following areas:

The USGS **Office of the Director** performs chief executive officer and chief operating officer responsibilities.

The science mission area **Associate Directors** establish program direction and goals, and serve as science advisors to the Director in their respective program areas.

The **Regional Directors** exercise line management responsibility for the science centers and implement science projects on the landscape.

The **Office of Budget, Planning, and Integration (BPI)** secures funding resources needed for the USGS to perform its mission goals, facilitates information sharing internally and externally, provides oversight of the internal controls process and the USGS Working Capital Fund, and provides in-depth analysis of budget and performance data for the USGS to understand, anticipate, and respond to the changing demands resulting from public policy decisions and science needs.

The **Office of Communications and Publishing (OCAP)** guides and conducts external and internal communications and provides publishing and Web development services. The Science Publishing Network (SPN) prepares science reports and maps for publication, and provides services including technical writing, editing and graphical displays. This information is widely used across the Nation by members of Congress and their staff, other natural resource planners and managers, recreational hunters and hikers, emergency response officials, and the media.

The **Office of Science Quality and Integrity (OSQI)** establishes and implements standards for scientific integrity and excellence and administers programs for ethics, education, development, and collaboration

including the USGS Office of Ethics, the Youth and Education in Science program, the Mendenhall Postdoctoral Fellowships, bureauwide education activities, and the Office of Tribal Relations.

The **Office of International Programs (OIP)** enhances the USGS scientific mission by providing opportunities for USGS scientists to interact with scientific partners abroad and extend research and investigations to other countries. The OIP supports the development and conduct of a broad spectrum of international activities involving scientific cooperation and assistance in geological, hydrological, biological, and geospatial research and scientific investigations. The OIP provides guidance and representation to domestic and international agencies and organizations in matters pertaining to international scientific activities of the USGS.

The **Office of Diversity and Equal Opportunity (DEO)** develops policies, programs, and guidelines to ensure proper implementation of Equal Opportunity laws and regulations and provides leadership and oversight for the USGS Diversity and Inclusion Plan.

The **Office of Administration (OA)** establishes policies, manages, coordinates, provides oversight and conducts operations in the areas of accounting and fiscal services, general services, security, safety and occupational health, acquisitions and grants, internal controls, technology transfer, facilities and property, environmental protection, human capital programs, including human resources and employee development. The Associate Director is the Chief Financial Officer (CFO) and Designated Agency Safety and Health Official (DASCHO).

Program Performance

Enhancing Discoverability of USGS Science – USGS publications and data are now more accessible to other scientists, decisionmakers and the public because of implementation of Digital Object Identifiers and registering them in CrossRef, a universal, cloud-based "card catalog" for scientific and other data. The Digital Object Identifier System enables publications and data to be individually identified and more easily discoverable through bibliographic indexes such as Google Scholar and Scopus. Links to scholarly publications and data can be lost when Web pages are deleted or information is reorganized, but Digital Object Identifiers (DOI's) provide a persistent online locator, regardless of where the item resides now or in the future. The use of Digital Object Identifiers on USGS series publications is enhancing the discovery and use of USGS science in the science community and in the public. This supports the White House Open Data Policy and the Office of Science and Technology Policy's (OSTP) mandate to Increase Access to the Results of Federally Funded Scientific Research.

The USGS Web reengineering launched the new USGS Web site, *www.usgs.gov*, using open source content management software and hosted within Interior's cloud. This effort creates a more effective and manageable Web presence and provides Web-enabled technology, real-time access, social and collaborative cloud-based tools, and extensive use of mobile and tablet devices. The new site is customer focused, provides science-driven content, is mobile ready, uses industry best practices, improves search, Web site functionality and navigation and complies with Federal standards. A the new site incorporates insights learned through customer satisfaction data and usability testing. In addition, a new internal Web

site was also developed and implemented, which provides ready access to science news and business and workforce management information.

Positioning the USGS workforce to meet future science requirements – The third phase of the bureauwide workforce planning effort synthesized the first two phases to create bureau-level workforce planning strategies. A bureau workforce plan and bureau-level actions required to ensure the workforce needed to continue leadership in Earth science were developed. In 2015 and future years, they will be used to guide initiatives at the bureau level, particularly in the areas of skill set gaps, workforce flexibility, diversity, and succession planning.

Succession Planning – The USGS Office of Human Capital (OHC) served as a pilot organization during 2014 to facilitate the development and implementation of a succession planning process. Building on this pilot effort, and as noted in the bureau workforce plan, the USGS will conduct a succession planning process for the leadership ranks (GS-14 and above) in 2015. This work will initially focus on positions in the Senior Executive Service, and later on leadership positions at the GS-14 and 15 levels. The USGS will also conduct additional pilot efforts at different organizational levels. These concurrent efforts will help solidify a succession planning methodology and tools that can be applied more broadly across the USGS and ensure a talent pool of employees with the skills needed to assume key positions.
The USGS continued its dedication to effective leadership and management by offering tailored training in specific skills appropriate to various career stages. For new supervisors, four week-long sessions of the USGS Supervisory Challenge course was provided to 100 new supervisors. This course covers the competencies required for supervisors during their first year of supervisory responsibility. A variety of assessment instruments are included in the course to provide supervisors with insights into their own preferences and behaviors. In addition, a multi-rater assessment tool has been implemented as an optional tool available to USGS supervisors to assess their progress in specific supervisory behavioral categories. Leadership training was provided to 193 employees across the bureau through Leadership Intensives, a two-day course that introduces leadership concepts, including the USGS guiding principles, to employees at all grade levels. In addition, the two-part series of Leadership 101 and Leadership 201, geared toward employees in grades 12 to 15, was offered to employees selected by nomination. One national-level Leadership 101 course was delivered to 26 employees, and one Leadership 201 was delivered to 25 USGS employees. For the first time, the Office of Organizational and Employee Development deployed a regional-level Leadership 101, providing leadership training to 26 employees of the Midwest Region.

Obtaining Science Resources – The innovative Scientific and Technical Support Services Contract (STSSC), which will streamline obtaining scientific research and technical support, was released in draft for industry comment. This contract will enable a more nimble response to new science project requirements. This contracting vehicle combines similar services across the landscape and will take advantage of competition among 8(a) companies, and reduces the number of multiple sole source awards. This will better serve USGS science in addition to fulfilling acquisition performance goals to improve competition rate for acquisitions and achieves economies of scale to the maximum extent possible.

Another innovative contract strategy, a cooperative agreement with the Southwest Conservation Corps (SCC) provides science, technology, engineering and mathematics (STEM) work experiences to youth by

providing jobs assisting USGS Science Centers with data collection and ongoing science research activities.

Ensuring Financial Health – Innovative science center financial health tracking tools originally developed to ensure effective management of sequestration-affected budgets continue to be used by leadership to prioritize use of financial resources, and maintain awareness of budget management to maximize science productivity.

In 2014, the USGS piloted the collections and intergovernmental payment system modules of Treasury's new Central Accounting and Reporting System (CARS). CARS intent is to improve Federal Trading Partner reconciliations, an effort to resolve their longstanding intra-governmental elimination issue. At the beginning of 2015, the USGS successfully implemented the rest of CARS and, ongoing efforts, will continue to refine and improve the process internally to ensure continual improvement of intra-governmental elimination reconciliations. Financial performance improved as measured by the Interior scorecard metrics, in Prompt Pay, EFT, and Charge Cards. The USGS implemented new financial management tools and control processes, and deployed a Business Process Consolidation (BPC) module to replace financial reporting software that is no longer supported.

Improving Efficiency and Effectiveness of Resource Management – The USGS met all Campaign to Cut Waste spending reduction goals for 2014 through a comprehensive education and management oversight program. A dedicated community Web site provides current information including status tracking, policy, and reference tools. The USGS has implemented effective conference-planning methods to provide data to manage conference attendance while maintaining USGS science-leadership in wider forums. The USGS will continue to monitor resource management performance against Campaign to Cut Waste targets.

Overhead - In 2014, USGS leadership directed a review and analysis of the management, support and infrastructure costs associated with conducting science, research, and monitoring at its science centers. When discussed as a unit, these costs are called “overhead” or “common services.” At the science center level, because there generally is not an appropriated funding source to pay the local overhead costs, both the appropriated and reimbursable funding are assessed a percentage to cover their share of science center-level costs. Science center common services costs include center costs that are not directly attributable to a specific activity or project, such as managerial, supervisory, administrative, and financial functions and related systems, as well as costs incidental to providing services and products, such as postage, training, miscellaneous supplies and materials. More information on both bureau and science center overhead is found at the end of the Sundry Exhibits Section. The review and analysis was done to address questions on what is included in these costs, why the overhead rate differs from science center to science center, and identify opportunities to improve consistency in determining and describing overhead rates.

Leadership in Environmental Stewardship – The USGS has implemented an Environmental Management System (EMS) in order to ensure compliance with environmental policy and regulation; prevent pollution; and achieve Administration goals for reduction of greenhouse gas emissions. The EMS is a comprehensive structure to measure and manage the USGS’s environmental impact and includes an

overarching policy, an executive management council, cross-functional teams, bureau-wide training, database tools, metrics and performance goals to measure compliance, and external audits to independently evaluate and verify program effectiveness. In addition to pollution prevention, and environmental compliance, the USGS includes sustainability goals for greenhouse gas and water consumption.

A key component of the EMS is to maintain objective criteria to determine the significant environmental impacts resulting from USGS science activities, identify the applicable legal requirements, and prioritize objectives and targets to correct existing impacts and prevent future impacts. Greenhouse gas emissions and water consumption data are also calculated and used to measure progress. A baseline was established to measure and monitor progress. In 2014, objectives and targets were established for reducing greenhouse gas (GHG) emissions, improve hazardous materials management, increase awareness of the National Environmental Policy Act and reduce solid waste generation.

An alternatively financed Energy Savings Performance Contract (ESPC) worth $12 million was awarded which will produce energy and water cost avoidance of $660,000 per year. This contract will enable infrastructure improvements to USGS facilities including energy management control systems; heating, ventilation, and air conditioning (HVAC) improvements; lighting upgrades and controls, and renewable energy systems installation. The ESPC will reduce the USGS's energy consumption by 15 percent and potable water use by 5 percent. The ESPC will also help achieve total energy reduction of over 30 percent, from its 2003 baseline year, and over 26 percent total reduction of water from its 2007 baseline year. Additionally, the ESPC will help reach the USGS GHG Scope 1 and 2 emission-reduction goal of 20 percent from the 2008 baseline.

The Office of Management Services has developed an Environmental Compliance Management and Auditing System. As a part of the system, the Web application framework and platform will be used to manage environmental documents and records. It will also be used to generate workflows to meet science centers' environmental needs. A third party software tool is integrated to facilitate environmental audits conducted at the science centers. The findings from the audits will be documented and tracked. The workflow generated by the software tool will facilitate development and implementation of corrective actions. Upper management can use this tool to monitor the status of environmental compliance and progress of science centers in meeting various environmental goals. Training was provided to USGS staff during 2014 on the use of the Environmental Compliance Management and Auditing System. Additional training will be provided to the Collateral Duty Environmental Protection Coordinators in 2015.

Technology Transfer – The Federal Technology Transfer Act, 15 USC 3710 as amended, requires each Federal laboratory having 200 or more full-time scientific, engineering and related technical positions to establish a research and technology application function. Within the USGS, this function is housed in the Office of Policy and Analysis where staff service USGS Science Centers and offices throughout the country. USGS science and research contributes to a broad range of valuable collaborative projects in the private and academic sector. In 2016, the USGS will continue negotiating and drafting Cooperative Research and Development Agreements (CRADAs), Technical Assistance Agreements (TAA), Facility Service/Use Agreements (FSUA), Material Transfer Agreements (MTA), and Patent Licenses. This office also manages the USGS intellectual property and inventions program; markets USGS technology

opportunities and technical assistance to industry, non-profits, academic institutions, and State agencies; and provides training to USGS personnel on technology transfer and intellectual property protection.

During 2014, the USGS increased its technology transfer activity both in terms of number of collaborations and projects and reimbursable funding. The USGS executed 10 new CRADAs and over 200 new TAAs, making for 27 active CRADAs and more than 300 active TAAs. The USGS had more than 30 specialty analytical laboratory services providing unique capabilities to the United States, private sector partners, and academia. New facility use agreements executed during 2014 totaled more than 220. The total partner contributions from these various types of technology transfer agreements exceeded $8.5 million.

The table below page summarizes the number of technology transfer projects in 2014.

Active	Total Number	Private	Non-Profits	Academic Institutions	Government Entities	International Entities	Partner Contributions ($)	USGS In-Kind Contributions ($)
CRADAs	27	22	1	0	1	3	1,689	965
TAA	203	70	43	33	21	36	6,802	2,619
Patent Licenses	13	12	0	1	0	0	50	0

Youth and Education in Science – Investing in the future of the USGS workforce is the main task of the Youth and Education in Science (YES) office. Through funding of salary and benefits, distributed via competitive processes, the YES office provides incentive for USGS managers to respond to the Agency Priority Goal (APG) on Youth Stewardship and the Secretarial priority to engage the next generation of scientists and science support staff. In collaboration with USGS Human Resources staff, the YES office helps USGS hiring officials understand how to fully utilize the Pathways hiring authority for recruitment of underserved populations. In addition, the YES office helps managers understand flexible options for staffing their projects with students, utilizing student contracts and cooperative agreements with corps organizations in support of the 21st Century Conservation Service Corps.

In 2014, YES funds supported 180 youth as interns (61 in Career appointments), student contractors and AmeriCorps members in support of the USGS Science Strategy at 59 Science Centers, program offices and Cooperative Research Units across the Nation. YES funds combined with USGS Director's Office funding to provide cost efficient and valuable research assistance on 49 USGS science projects through National Association of Geoscience Teachers (NAGT) internships. Through the NAGT program's direct hiring authority, students nominated from undergraduate geoscience field camps are matched to USGS science research projects best suited to their skills and abilities, allowing the students to participate in cutting-edge field- and office-based work. Since its inception in 1965, over 2,200 students have participated in the NAGT program, with an impressive number of participants moving on to distinguished careers with the USGS, academia, or industry. To underscore the importance of working with underserved communities, YES funds supported four student contractors through the Denver Mayor's

Program and five graduates of the University of Texas at Austin's GeoForce program. These programs target a diverse population of students from inner city and rural schools through hands-on science.

Connecting Science Quality Best Practices Together – OSQI provides internal controls on Fundamental Science Practice (FSP) and Information Product Data System (IPDS) to demonstrate evidentiary processes for maintaining the quality of USGS science. Connections are in place for ensuring science quality best practices are followed for approving and releasing publications; helping the bureau grow the next generation of Federal scientists through Mendenhall postdoc high school and college internships; evaluating USGS research, development, and senior scientists; and maintaining scientific knowledge base associations through scientist emeritus. In 2014, 7,315 products were approved in compliance with FSP and tracked using IPDS—4,047 new interpretive products were approved by Bureau Approving Officials in OSQI and 3,268 interpretive (previously published) and non-interpretive products were approved at the USGS science center level. Additionally, in 2014, the OSQI completed the Mendenhall Fellows Recruitment Round 14, which resulted in the hiring of 29 new Mendenhall postdoctoral fellows.

Meeting Science and Information Quality Requirements – FSP policies govern the quality and integrity of the USGS scientific process including the development, review, and release of scientific information. These policies provide assurance of high quality, accessible data availability to land-management decisionmakers, the larger scientific community and the public. New FSP policies on data management (including data lifecycle elements), metadata, data release, data preservation, and software release aimed meeting OMB and OSTP open data and open access requirements were developed in 2014, and are planned for release in 2015 as interim policy for a period of time to allow appropriate implementation the requirements. In 2015, updating other FSP related policy on topics including information product planning, authorship and credits in information products, and using outside publications are planned. The IPDS provides the official record of adherence to the FSP during development, peer review, and final approval of USGS scientific publications. In 2014, 2,508 USGS employees participated in IPDS workflows, resulting in improved FSP compliance. In 2014, OSQI coordinated the completion of three Information Quality Act requests for corrections (initially received in 2013) and the posting of 15 peer review related documents for influential USGS products were posted to the USGS Peer Review Agenda Web site.

Updating the Department's Science Integrity Policy and Developing Training and the USGS Science Integrity Policy – OSQI played a significant role in helping the DOI bring its updated Science Integrity Policy to completion in 2014. In 2015, OSQI is leading efforts to develop a draft DOI Learn Scientific Integrity training module, planned for release and will initiate work to update the USGS science integrity policy for consistence with the DOI policy.

Supporting Native American Needs – The USGS Office of Tribal Relations (OTR) continues to foster relationships with Indian Tribes and Alaska Native Villages that support increased scientific research collaboration with the USGS. The OTR supports annual trainings on a variety of scientific topics designed to increase the capacity of tribal natural resource departments. The OTR also supports USGS scientists who work with Tribal Colleges and Universities (TCUs) such as Salish Kootenai College, Northwest Indian College and Southwestern Indian Polytechnic Institute to provide mentoring and to

supplement and improve curriculum offerings in subjects such as hydrology and remote sensing. The OTR also funds internship opportunities for work on USGS research projects conducted on tribal lands. In 2014, the OTR designed and provided support for the third year of the Native Youth in Science – Preserving Our Homelands summer science camp. The USGS partnered with the Mashpee Wampanoag Tribe on this unique pilot project that pairs USGS scientists with tribal culture keepers to ensure that course material on geology, hydrology and ecology is presented to tribal youth (grades 5-7) in a context that interweaves Western science and traditional ecological knowledge (TEK). In 2014, the OTR funded research examining weather events recorded in early Native Hawaiian-language newspapers in order to access information on volcanic activity that may not have been recorded by western scientists. The OTR provided funding for USGS tribal outreach in 2014 and to continue in 2015 for Tribes in New Mexico and the Pacific Northwest, as well as funding the development of a tribal guide on cyanobacteria that can aid tribal natural resource staff identify potential threats to surface water. The OTR facilitated engagement in 2014 between the USGS and tribes impacted by Hurricane Sandy, and will continue in 2015 and 2016, as research continues on remediation of these impacts, as well as providing scientific data to help these tribes prepare for future storm events. In 2015 and 2016, the OTR will develop and implement a tribal emergency response data portal that will provide tribes with a streamlined way to access USGS data on natural hazards to help in the preparation of emergency management and mitigation plans. The OTR will continue in 2015 and 2016 to fund regional tribal engagement with the USGS, information transfer and capacity building, internship opportunities, and measures that ensure that USGS science is accessible to Native Americans for their natural resource management needs.

Activity: Science Support
Subactivity: Information Services

2014 Actual: $23.7 million (68 FTE)
2015 Enacted: $21.4 million (66 FTE)
2016 Request: $22.2 million (68 FTE)

Overview

The Information Services subactivity provides the critical information technology (IT) foundation for the USGS science mission by implementing advances in IT and computing capability and using them to facilitate research, data gathering, analysis and modeling, scientific collaboration, knowledge management and work processes. Additionally, this subactivity funds the USGS information security program, Capital Planning and Investment Control (CPIC), and federally mandated information activities such as Records Management, the Freedom of Information Act (FOIA), Information Collections, Section 508 Amendment to the Rehabilitation Act of 1973, and the Federal Advisory committee Act (FACA) program. This subactivity also supports the Department of the Interior (Interior) information technology transformation.

Information Assurance protects infrastructure and data from improper or malicious access or manipulation, protects the integrity and availability of science information, preserves the confidentiality of privacy and other sensitive information and ensures compliance with Federal IT mandates and regulatory requirements. Oversight is applied to IT security control implementation to ensure well-rounded information system management is used to increase the reliability of the technology supporting science information delivery. The Information Assurance office provides specialized security training to 10 major systems and over 100 subcomponents in the appropriate remediation of vulnerabilities, planning, and internal control implementation to ensure risks are managed commensurate with data sensitivity and mission requirements.

Telecommunications support timely transmission and sharing of emergency and routine data such as from earthquakes, flooding, and volcanic eruptions. This complex architecture is used to provide timely access to global environmental data to promote, protect, and enhance the Nation's economy, security, environment, and quality of life. To fulfill its responsibilities, the Telecommunications Program acquires and manages the investments for voice, data, video, and radio/wireless subsystems within the USGS, , to assist with capital investment funding. This component also provides regular voice and computer network services.

The USGS Video Program provides for the management and hosting of $1.3 million in video teleconferencing (VTC) infrastructure, which supports video and audio communications between scientists and their constituents as a complement to standard voice communications. With over 40 VTC endpoints throughout the Nation, the USGS has increasingly exploited its use to save on travel costs, enhance communications, and enable cost-saving telework initiatives.

The USGS Radio Program provides strategic and operational support to the science mission including radio frequency spectrum management for almost 1,000 radio frequency assignments and risk management for over $85 million of radio-enabled assets including maritime mobile, hydrological, ground penetrating radio, weather radar, satellite communications, water metering systems, underwater communications systems, aeronautical mobile and wildlife tracking systems.

The USGS Voice Program encompasses a wide range of services consisting of a system of highly reliable, dedicated voice circuits working in conjunction with a switching and conferencing system to create voice loops. These voice loops interconnect the 127 different voice distribution systems and additional landlines that support the diverse scientific centers. A WCF provides for voice equipment upgrades and replacements and assistance to bureau sites in PBX upgrades. A Blanket Purchase Agreement (BPA) was established to allow for standardization on a single, consistent voice platform, thus reducing the cost for equipment and support.

The USGS Data Network Program provides the necessary tools for scientists to share substantial amounts of information and data across the network. It supports critical hazards programs that monitor earthquakes, floods, and volcanoes across the Nation and around the world. The Telecommunications Program manages the wireless local area networks (WLAN) that enable users to connect to the USGS network via laptop, smartphone and tablet, and move freely about without losing connectivity. The USGS is moving toward an increasingly wireless workplace; this goal will be significantly enabled by the finalization of an enterprise WLAN contract which will reduce overall costs. WLAN boosts the efficiency of employees, saves on cabling costs, and makes the network more accessible.

Computing Infrastructure provides data storage and Web-based business collaboration tools, directory services, Internet and Intranet services (EWeb), GIS support, and a “one-stop shop” service desk. The primary services include secure authentication, group policy management, directory services,, IT asset management, and security compliance monitoring. E-mail is the primary avenue of delivering information quickly throughout the USGS, as well as to cooperators and colleagues throughout the world. It allows scientists to receive notifications quickly from automated systems that send information on earthquakes, tsunami, hurricanes, and flooding around the country and the world.

Information Management conducts planning for future requirements, prevents loss of capability through investment control and supports sound investment strategies. In addition, Information Management oversees a broad suite of activities that support information discovery and delivery and ensures the collection, storage, sharing, preservation and publication of scientific data according to Federal laws and regulations. The USGS Enterprise Web (EWeb) program is a network of people and resources focused on providing access to USGS digital resources. The EWeb Program includes a secure and reliable hosting infrastructure through the National Web Server System (NatWeb). The EWeb also provides policies, guidance, services, and tools to enable the effective delivery of USGS science and information products.

The Investment Management Program works to ensure that IT funds are spent in the most efficient and effective manner to support the science mission of the USGS. The program works to increase the use of

enterprise contracts and other strategic sourcing approaches combined with more standardization of tools and services to optimize IT spending and support a great amount of scientific research.

Capital Planning and Investment Control (CPIC) is a decisionmaking process designed to ensure that IT investments integrate strategic planning, budgeting, procurement, and the management of IT in support of the USGS mission. The USGS Investment Portfolio is projected to be $146 million in 2016.

The **USGS DOI Enterprise Services** supports the Interior's IT Transformation, technology streamlining and cost and service efficiency initiatives through contributions to Interior's IT Working Capital Fund.

Program Performance

Information Services has been confronted with competing mission challenges resulting from natural disasters and continued austere budgets. However, Information Services continues to meet the increasing demand for mobile science information delivery services. Working in collaboration with bureau executives, Information Services has instituted strategic adjustments to mission priorities and activities allowing the organization to remain resilient, adaptable, and agile while maintaining core services and delivering the expected high level of customer service. Across the organization, Information Services has undertaken prudent workforce shaping and realignment to define the outline of a 21st Century comprehensive workforce that is and will continue to be responsive to mission needs. Information Services focuses its service delivery on four key priorities: enhance science information delivery; protect science data and assets; maintain operations; and support the IT Transformation initiatives.

Science Information Delivery – To enhance public access to USGS data, Information Services established collaborative partnerships with the USGS mission areas to achieve the Administration's digital strategy goals of increasing cross-agency and public access to government data. Through these collaborative relationships, USGS total high value datasets submitted to data.gov now exceed 900,000 and have ranked the USGS in the top three Federal organizations in 2013 and 2014.

The USGS is leveraging Web-enabled technology, real-time access, social and collaborative cloud-based tools, and extensive use of mobile and tablet devices. Information Services, in partnership with the USGS's Office of Communication and Publishing (OCAP), embarked on a USGS Web reengineering effort in 2013, to create a more effective and manageable Web presence. The goal of this effort was to make USGS science more accessible and useful for customers and partners. In 2014, Information Services has continued these efforts to the point of a prototype Web presence. These activities and accomplishments support the White House Digital Strategy goal to enable the American people and an increasingly mobile workforce to access high quality digital government information and services anywhere, anytime, on any device.

The USGS prototyped the customer focused, externally facing Web site *www.usgs.gov*. This prototype provides enhanced access to science-driven content including, RSS feeds, tweets, videos and photos. It is mobile ready, uses industry best practices, improves search capabilities, and Web site functionality and navigation. Additionally, the prototype site incorporates customer driven improvement garnered from satisfaction data and usability testing.

The USGS plans to aggressively leverage the IT Transformation Cloud services (public cloud) integrated with internal USGS private cloud capabilities for the transition of digital and paper science products. In 2014, the USGS established the bureau direction on cloud services, and currently is working aggressively toward implementation. A pilot program is slated for 2015 and will lead to increased USGS visibility.

Preserving Science Data for Future Generations – The USGS is protecting science data and assets by leveraging the concepts and best practices of a "Service on Demand" delivery solution. Information Services transitioned the organization from analog to digital for the USGS Freedom of Information Act (FOIA), Information Collections (IC), Records, Information Quality (IQ), and Information Delivery programs. These programs worked with stakeholders to update guidance, improve data quality, automate processes, transfer paper products to digital, and utilize modern technologies to extend access to the public for current holdings.

The USGS continued its focus on preserving science for future generations by ensuring that data from 20 science projects were preserved as one-of-a-kind, high-value datasets, documents, reports, maps, imagery and other information. The Records Program analog to digital preservation activity is the culmination of a 6-year effort that has successfully "saved" data from 113 science projects that span more than 100 years of research in energy resource availability, water, ecosystems, climate, hazards, and geography. Now preserved and digitally accessible, these data are being made available to the science community, stakeholders, and the public for the first time, serving diverse scientific and marketplace needs today and for future generations. In 2015, data from an additional 18 science projects are scheduled for preservation.

Improving the Operational Infrastructure to Ensure Science Success – Information Services continues to spearheaded strategic sourcing initiatives in IT acquisition spending for administrative and cost efficiencies. In 2014, an additional two multi-year strategic sourcing initiatives were successfully implemented. These strategic sourcing initiatives consolidate hundreds of separate procurement actions, standardize technology, streamline procurement's, lower costs by 20 to 55 percent, and reduce administrative overhead.

Improvements in the bureau's computing infrastructure includes improving efficiencies through the optimization data center services, acceleration of virtualization efforts, and replacement of outdated equipment with more energy efficient devices, retirement of legacy services, and the consolidation/closure of data centers. Virtualizing applications allows the USGS to reduce operating costs for software, power, equipment cooling and labor. Across the USGS, the virtualization status is now above 40 percent and projected to be at 60 percent by end of 2015. Server reductions continue to occur through modernization and the USGS has successfully reduced its server count by 600 in 2014.

Information Services has also been closely coordinating with personnel across the bureau in the identification, planning, and execution of targeted data center closures. Closures have been accommodated through consolidation of functionality to sister data centers within the bureau. As Interior implements their planned shared service centers, consolidation to these facilities will be considered. Three data centers were closed in 2014, with an additional five centers in 2015, depending upon final evaluations and available implementation funding.

In telecommunications, the USGS is working with Interior to upgrade the USGS telecommunications backbone to support cloud and emerging technologies. The USGS is performing an inventory of all locations to assess network capacity planning and ultimately upgrading the USGS network to the next generation of technology to support science. In 2014, these next generation improvements were made to telecommunication services including implementing wireless services, upgrading circuits and modernizing wide area network infrastructure resources. These "wireless high-speed" foundational upgrades enhance the agency's ability to collect, process, synthesize and disseminate information at near real-time basis.

In 2014, the Radio Program Management Office developed a strategic plan and preliminary budget for planned radio frequency spectrum relocation initiatives involving the 1695-1710 MHz, 1755-1850 MHz, 2200-2290 MHz, and 410-420 MHz radio frequency bands. In the years 2015–2020, the USGS plans to vacate or share these frequencies with the public sector in accordance with the Commercial Spectrum Enhancement Act (CSEA). In an effort to work collaboratively with USGS Science Mission Areas on the Spectrum relocation and share emerging technologies and challenges, Information Services formed a strategic Radio Advisory Committee in 2014.

In 2013, the USGS undertook a major architectural initiative to improve collaboration and workforce capabilities with the implementation of a greatly enhanced Web-based platform. This new, enhanced platform is the underpinning infrastructure supporting the bureau's need for an integrated collaboration tool that meets science and administrative demands for information capture, processing, synthesis and dissemination efforts. As a result of the capabilities this enhanced platform provides, the USGS transitioned over 100 key tools and developed new forms and applications that support science research, human resources, budget, finance, internal controls, property, facilities, safety and other compliance activities.

The USGS also enhanced their information security by augmenting Continuous Monitoring Capabilities and increasing requirements for vulnerability management. The bureauwide implementation of IBM Endpoint Manager (IEM) solution allowed all assets to be accounted for and improved monitoring of all systems. IEM improved the USGS's ability to develop security dashboards and convey the security posture to appropriate levels and affect corrective action. The USGS was the first Interior bureau to complete the implementation of IBM EndPoint manager and co-lead the DOI and Department of Homeland (DHS) initiative. At present, the USGS has over 16,000 clients reporting to IEM.

In 2014, the organization improved and continued the implementation of consistent and measurable information security processes and controls; provided over 53 training courses; migrated five systems under the new Assessment and Accreditation (A&A) model; maintained A&A for 100 percent of all reported IT systems/enclaves; increased and automated a number of common security controls; and developed updated standard operating procedures. Because of these activities, the USGS improved its Federal Information Security Management Act (FISMA) ratings; improved staff knowledge, skills and abilities; improved internal controls; improved the bureau's ability to detect and mitigate IT security risk; and completed remediation of reported risks that could have significantly affected operations.

Information Technology Transformation Initiative – In support of the Interior's Information and Technology Transformation Initiative (ITT), the USGS has been collaborating with the DOI CIO on all Transformation activities. The USGS, along with the Bureau of Land Management (BLM), Bureau of Reclamation (BOR) and National Park Service (NPS) helped shape and refine the concept of DOI IT Transformation to a more Shared Services methodology. All DOI ITT initiatives are supported by USGS subject matter experts through leadership of Interior teams and participation at planning meetings. The USGS was co-lead on the DOI IEM project and the DOI Telecommunication project, as well as chair of the DOI End User change control board. USGS leadership on these DOI teams is critical to the mission of the USGS.

In 2014, the USGS assisted the BLM in establishing the Shared Services Data Center concept at the Denver Federal Center (DFC). The USGS, along with the BOR, and BLM will consolidate from seven data centers on the DFC to three. Enterprise services will be hosted out of the BLM and non-core type data center services will be hosted out of two USGS locations. The USGS currently hosts the IEM service for all Interior, providing application and technical expertise to Interior and other bureaus as needed.

Facilities

Activity: Facilities

		2014 Actual	2015 Enacted	2016 Fixed Costs and Related Changes (+/-)	2016 Internal Transfer	2016 Program Changes	2016 Budget Request	Change from 2015 (+/-)
Rental Payments and Operations & Maintenance ($000)		93,141	93,141	-2,408	0	16,314	107,047	13,906
	FTE	62	62	0	0	0	62	0
Deferred Maintenance and Capital Improvements ($000)		7,280	7,280	0	0	0	7,280	0
	FTE	0	0	0	0	0	0	0
Total Requirements ($000)		**100,421**	**100,421**	**-2,408**	**0**	**16,314**	**114,327**	**13,906**
Total FTE		**62**	**62**	**0**	**0**	**0**	**62**	**0**

Summary of Program Changes

Request Component	($000)	FTE	Page
Rental Payments and Operations & Maintenance	**16,314**	**0**	
Operations and Maintenance Stewardship	2,712	0	C-80
Reducing the Facilities Footprint - Cost Savings and Innovation Plan (CSIP)	11,602	0	C-80
Sustainability Investments	2,000	0	C-81
Total Program Change	**16,314**	0	

The 2016 Budget Request for Facilities is $114,327,000 and 62 FTE, a net increase of +$13,906,000 and 0 FTE from the 2015 Enacted. For more information on the Facilities Mission Area change, please see Section C, Program Changes as indicated in the table.

Activity Summary

The U.S. Geological Survey (USGS) Facilities Activity provides safe, functional workspace for accomplishing the bureau's scientific mission. Funds support basic facility operations; security; facility maintenance in compliance with Federal, State, and local standards; and provide a safe-working environment for USGS employees, visiting partners, and customers.

Assets include property consisting of land, buildings, or other improvements permanently attached to the land or a structure on it. The Department of the Interior (Interior) defines a facility as an individual building or structure. The USGS defines facilities to include all sites where USGS activities are housed and mission related work is conducted. Facilities typically provide space for offices, laboratories, storage, parking, shared support for cafeterias, conference rooms, and other common space uses. The USGS also classifies its eight large (greater than 45 feet in length) research vessels as laboratory facilities. Owned assets are usually part of a campus, for example, the Leetown Science Center includes all associated land, buildings, and other structures.

The Facilities Activity is comprised of two subactivities: Rental Payments and Operations and Maintenance (RP and O&M), and Deferred Maintenance and Capital Improvements (DMCI).

This Activity supports the Interior's goal of facilities improvement by tracking outcomes such as overall condition of buildings and structures, reduction of energy intensity by three percent annually; percentage of square footage that meets Executive Order (E.O.) 13514 sustainable building goals; and cost savings initiatives through space consolidations.

The Facilities program goal is to meet bureau science needs while optimizing facilities location, distribution, and use, to control or reduce costs. Objectives for meeting this goal are to—

- Coordinate facility planning with science planning to provide safe, high-quality workspace aligned with science needs.
- Develop Asset Business Plans to meet asset management goals, continue annual surveys, and cyclic condition assessments.
- Meet performance targets for improving space utilization, controlling rent and operating costs, and releasing unneeded space.
- Reduce deferred maintenance by renovating and constructing buildings and other facilities to replace assets otherwise no longer cost effective to operate.
- Establish an effective maintenance program at each owned facility to meet industry best practices.
- Increase co-location consistent with science program objectives.
- Achieve energy performance goals.

Facility Planning

The USGS utilizes site-specific Asset Business Plans (ABPs) that support the USGS Asset Management Plan (AMP). The ABPs are 5- to 10-year plans addressing specific needs of a field unit, campus, or region including all assets reported in the Federal Real Property Profile (FRPP). The USGS ABPs effectively address the life cycle issues and characteristics of a site's real property assets. For the local facility or program manager, the ABPs help provide a profile of their current facilities, size, staffing, and utilization rate. The plans also anticipate future needs, create an awareness of recurring and one-time space costs, plan mission operations with facilities in mind, and identify issues that may qualify for additional funding. The ABPs are also used as annual action plans to direct bureau area resources where they are most needed to support the USGS mission.

The USGS has been aggressively pursuing actions to reduce the USGS footprint and to achieve an office space utilization-rate of 180 square feet (SF) per person. The USGS scrutinizes all space actions, irrespective of how the space is acquired, to work toward set goals in the Office of Management and Budget's (OMB) "Freeze the Footprint" policy. This broad-based approach allows the bureau to manage all the space in the portfolio holistically. To control the footprint and to administer the space policy, the USGS developed an automated, centralized Space Action Approval and Waiver (SAAW) process for all space actions. This process ensures each space action does not increase the bureau's footprint, works toward the utilization standard, and keeps costs under control. This tool uses alternative analyses to help manage the footprint and allow for a more informed decisionmaking process regarding facilities investments and space actions.

The USGS relies on General Services Administration (GSA) -owned and -leased buildings for about 67 percent of the space it occupies. The USGS has no ability to reduce fixed rental rates at these sites and can only offset the higher facility costs by vacating space. Therefore, the primary emphasis is on improving space utilization; disposal of underutilized assets; consolidating operations within; and relinquishing space to GSA provided offices, laboratories, data centers, and warehouses at major USGS centers in Reston, VA, Denver, CO, and Menlo Park, CA.

The USGS owns 271 buildings situated on 2,157 acres. These buildings total 1.26 million SF and have a replacement value of approximately $367 million. Additionally, the USGS owns 284 structures with a replacement value of $110.4 million. The owned inventory includes ten ecological science centers; five ecological field and research stations; one land use science center—the National Center for Earth Resources Observation Science (EROS); ten geomagnetic, seismic and volcano observatories and several miscellaneous owned properties such as streamgage stations and warehouses and a storage annex. The USGS also owns eight large research vessels that have operations and maintenance costs that are comparable to those of a USGS building. These vessels exceed 45 feet in length and perform overnight research to support biological, water resources, and marine geology research. Five of the vessels operate on the Great Lakes; two operate in California, and one in Alaska.

As part of the Strategic Facilities Master Plan (SFMP), USGS facilities were ranked in terms of their mission dependency using a tool called the Asset Priority Index (API). Although the largest concentrations of employees are in GSA-controlled space in Reston, VA, Denver, CO, and Menlo Park, CA, 15 of the top 20 mission-critical assets are owned assets in other locations. These owned assets have specialized capabilities positioned on the landscape to address specific science issues.

For example, the National Wildlife Health Center (NWHC), in Madison, WI, certified by the Centers for Disease Control and Prevention (CDC) to receive and work with “select” disease agents, maintains a high-security infectious disease facility that operates at the Biological Safety Level 3 (BSL-3). The U.S. Department of Agriculture (USDA) has also approved the NWHC to import, export, and transport domestic animal infectious agents. The NWHC is the only Federal institution dedicated to understanding the role of wildlife health in conservation and public health. In the case of wildlife disease emergencies, the NWHC is the lead for Interior under the Department of Homeland Security’s National Response Plan. A seven-feet-high cyclone fence surrounds the 24-acre NWHC tract. The entrance to the science center has a high-security-card access gate. Each building has security card readers for entrance and security keypad systems. Twenty-four hour access to restricted areas is limited per CDC Select Agent requirements for BSL-3 laboratories. An additional cyclone fence further secures the Tight Isolation Research.

Another location is the EROS Data Center (EDC), centrally located in Sioux Falls, SD. When the idea of an EROS Center was conceived, it was decided that it needed to be centrally located for receiving data as Landsat satellites passed over the United States. A location was required where the EDC ground station could see the satellites as they orbited over the east coast, west coast, and most of Canada and Mexico (i.e., the center of North America). The central location was a valid requirement 40- plus years ago and is a valid requirement yet today. The EDC’s location eliminates the need for locating a ground station on

both the west coast and the east coast to ensure coverage of the conterminous United States—EDC does all that from a single site.

The USGS's five-year Space Management Plan (SMP) supports the bureau's SMP and Site-Specific ABPs, providing a framework, strategic vision, and plan of action for effective bureau management of GSA provided space, USGS direct leases, and owned property. It is used by USGS management to implement bureau space goals, including consolidation, co-location, and disposal. Information contained in the Bureau Asset Management Plan focuses on mission dependency and program requirements for space.

Cost Savings and Innovation Plan (CSIP) – Space savings are integral to rent and operations management. The USGS realizes space savings when locations are able to consolidate space or relocate to space with lower costs. The USGS is actively assisting the Interior to meet its cost savings and innovation targets by proceeding with a CSIP. The USGS's goals under the CSIP are to reduce its footprint and costs, and move toward a 180 SF per person utilization standard. In addition to implementing a centralized space action approval process to focus on meeting these goals, the USGS also established a five-year planning process for CSIP projects. Implementation included a ranking, scoring and approval process, as well as identifying funding for CSIP projects. The USGS leveraged existing software for project inventory, status updates, calculating savings and cost avoidances. The USGS is prioritizing and funding CSIP projects with the shortest payback period while significantly reducing the bureau's footprint and costs.

2015 Congressional Directive – USGS Facilities Footprint

The committee supports this long-term effort to reduce the USGS facilities footprint and directs the USGS to include a summary of the completed renovations and analysis of savings achieved in its fiscal year 2016 budget request, as well as projected future savings for the bureau. The following table responds to the 2015 Congressional Directive – USGS Facilities Footprint.

2016 Cost Savings and Innovation Plan

Project Name	Amount Funded in 2016 Request	SF Reduction	Projected Annual Savings ($)
Denver Federal Center - Move to Building 25, 95, & 810 - From older GSA buildings to newer/more suitable buildings (Phase 3 & 4)	350,000	-22,800	-252,000
Menlo Park, CA - Building 15 Library Consolidation (Phase 2 of 2)	1,860,000	-21,900	-570,000
Boulder City, NV - Collocation with Bureau of Reclamation (Phase 3 of 3)	793,000	-3,100	-278,000
Denver Federal Center - Building 20 Space return South-End (Phase 2 of 2)	450,000	-9,200	-141,000
Texas Water Science Center Consolidation - Wichita Falls	487,000	-7,500	-150,000
Denver Federal Center - Building 25 Computer Room Consolidation with BLM	230,000	-5,300	-108,000
Menlo Park, CA - Building 9G - Release Entire Building	1,355,000	5,200	171,000
Menlo Park, CA - Building 3 - Release Entire Building	1,754,000	-30,700	-786,000
Reston, VA - National Center Consolidation (Phase 2)	4,323,000	-43,000	-1,247,000
Total	**11,602,000**	**-138,300**	**-3,361,000**

The USGS is utilizing the Financial and Business Management System (FBMS) to track the bureau's facilities cost at the asset level. The system allows for improved facility planning and reporting to Interior.

Maintaining America's Heritage is Interior's commitment as a steward of priceless and natural resources to preserve and maintain operational facilities and major equipment. Provided through the USGS 2016 Facilities budget this includes an estimated $38.9 million, $7.3 million for DMCI, including facilities projects, equipment maintenance, maintenance management, condition assessment and project planning; and $31.6 million for operations and maintenance at many of its unique science centers and one-of-a-kind labs such as the NWHC; the Denver Ice Core Lab, a premier facility for examining, sampling, and analyzing ice cores from some of the most remote places on Earth; and EROS, specifically located and equipped to collect, process and distribute remotely sensed land data and archive for users worldwide.

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Activity: Facilities
Subactivity: Rental Payments and Operations and Maintenance

2014 Actual: $93.1 (62 FTE)
2015 Enacted: $93.1 (62 FTE)
2016 Request: $107.0 (62 FTE)

Overview

The Rental Payments (RP) and Operations and Maintenance (O&M) Subactivity provides the USGS with funding needed to meet asset management goals and carry out Executive Orders (E.O.) related to Federal space.

In 2016, the USGS plans to spend $137.6 million on rent and operations and maintenance. Of these costs, 77 percent ($107.0 million) are funded through this subactivity. Reimbursable partners (19 percent) and science programs (4 percent) fund the remaining costs. In 2016, the total facilities rent cost is estimated to be $98.8 million. Approximately 25 percent of rent and operations and maintenance funds are spent on USGS owned properties; these assets are unique and mission critical in the USGS portfolio.

The USGS has a fixed cost reduction of $2.5 million in the Rental Payments and Operations and Maintenance subactivity based on the rent reduction calculation in OMB's Exhibit 54, the document used to calculate increases or decreases in GSA rent estimates covering all changes such as lease and operating cost. The USGS shows a rent cost reduction due to aggressive efforts to reduce space at three of its largest centers and through co-locations. The calculation in OMB's Exhibit 54 does not however include adjustment for any increases in cost for Operations and Maintenance of owned facilities. These increases are mainly due to inflation creating a shortfall in the Operations and Maintenance component of the Rental Payments (RP) and Operations and Maintenance (O&M) subactivity.

The RP cost component provides rental payments for space occupied by the USGS to the GSA, other Federal sources, private lessors, and cooperators. The USGS has unique facility requirements for supporting science functions and relies heavily on the GSA to meet those needs, including modern laboratory space. The USGS occupies approximately four million square feet of rentable space in about 167 GSA buildings nationwide, making the USGS one of the largest users of GSA space within Interior. Approximately 21 percent of USGS space is owned; the GSA, direct leases, and cooperative and interagency agreements provide the remaining 79 percent.

The O&M component provides funding for basic facility operations; security; facility maintenance in compliance with Federal, State, and local standards; and provides a safe working environment for USGS employees, visiting partners, and customers. Maintenance involves the upkeep of USGS owned facilities, structures and capitalized equipment, necessary to maintain the useful life of the asset. This includes preventive maintenance; cyclic maintenance; repairs; rehabilitation; replacement of parts, components, or items of equipment associated with the facility; adjustment, lubrication, and cleaning (non-janitorial) of

equipment associated with the facility; periodic inspection; painting; reroofing; and resurfacing. Also included are special safety inspections and other activities to ensure smooth operation and to prevent breakdowns; scheduled equipment servicing (such as that for heating, ventilation, and air conditioning equipment); and maintenance for owned facility-support equipment such as snowplows and landscape-maintenance vehicles.

Operational costs at USGS owned, and some leased, facilities include electricity, water, and sewage; gasoline, propane, natural gas, diesel, and oil; janitorial services; grounds keeping; waste management and disposal; vehicles operated solely in direct support of operating the facility; annual certification for building systems such as fire systems, fire extinguishers, backflow preventers, and fume hoods; and upkeep standards necessary to assure the anticipated useful life of the vessels, salaries and benefits of marine professionals operating the vessel, fuel, docking fees, inspections, minor repairs, cyclic maintenance, and at least one vessel haul-out per year. In addition to maintenance costs, salary costs associated with onsite staff responsible for the day-to-day operations of the facility and for maintaining it in operating order are included in the subactivity.

Since 2011, there has not been sufficient appropriated facilities funding to fully cover the bureau's rent and O&M costs. The result of this shortfall requires the bureau science programs to use appropriated science funding to pay for facility costs. This impacts the USGS science mission and directly reduces the amount of funding available for science research. In recent years, the bureau has done what it can during the formulation process to "keep this line whole," diverting science dollars on the front end of formulation processes to counterbalance any fixed cost reductions and not further contribute to the shortfall. However, it has become increasingly difficult to bridge this gap due to unfunded uncontrollable inflationary increases. The proposed increase in Operations and Maintenance Stewardship will enable the bureau to use more of its appropriated science funding for its science mission rather than funding facilities costs.

Program Performance

The National Historic Preservation Act (NHPA) (54 U.S.C Section 300101et seq.) was signed into law in 1966, requiring all Federal agencies to consider how their projects will have an effect on historic property. Section 110 of the NHPA sets out the broad historic preservation responsibilities of all Federal agencies and is intended to ensure that historic preservation is fully integrated into the ongoing programs managed by the agencies. Under the facilities activity and in compliance of this Act, the USGS has continually evaluated its assets inventory to identify and evaluate which properties may be historic as part of its facilities Comprehensive Condition Assessment Program. As part of E.O. 13327 "Federal Real Property Asset Management," the results of the historic evaluations are transferred to Federal Real Property Reporting through the Federal Maintenance Management System (FMMS). To date, 152 real property assets have been historically evaluated. The USGS will continue to evaluate all of its properties, which is anticipated to continue through 2021.

The CSIP has provided the USGS with the ability to reduce its footprint by more than 540,000 rentable square feet (RSF) from 2012 through 2014. By 2016, the USGS anticipates an additional reduction of 175,000 RSF; bringing the overall footprint reduction to 715,000 RSF. This is a 12 percent decrease of

the USGS space portfolio since 2012. These efforts focused on the USGS three major centers in Reston, VA, Denver, CO, and Menlo Park, CA. Each of these centers have successfully taken on major consolidation projects, reduced space requirements, actively sought co-location opportunities and vacated more-expensive space. The achieved results were the direct impact of the bureau's CSIP activity.

Through the GSA's Achievement Award Program, in 2014, the USGS was awarded the "GSA Real Property Award for Best Adopted Practices – Real Property Process Improvements" for their CSIP accomplishments. The GSA sought entries demonstrating innovation, creativity and best practices in four categories of Federal Real Property**: Asset Management, Sustainability, Workplace Innovation, and Best Adopted Practices.**

At the USGS National Center in Reston, VA, the USGS performs building operations under GSA delegation and has day-to-day control of most space assignments. The USGS supports Interior and other agencies, providing more than 266,648 SF of released space to other Federal partners. The most recent consolidation efforts included the USGS signing an agreement with the Interior's Business Center for their occupancy of 19,710 SF; an agreement with National Park Service (NPS) to occupy 37,284 SF of office and data center space; an agreement with the Department of Commerce (DOC) to occupy 21,482 SF; and an agreement with the Department of Defense (DOD) to occupy 12,500 SF of space at the Advanced System Center (ASC) building. In 2015, the USGS will continue to consolidate and actively seek additional Federal partners to improve the space utilization at the National Center.

The Denver Federal Center consolidation efforts included moving out of older GSA-owned buildings into newer and more suitable buildings such as Building 25, Building 95, and Building 810. Consolidations in 2013 and 2014 further reduced the USGS space requirement by an additional 185,000 SF.

In 2015, the Menlo Park Campus consolidation plan continues, and will return 36,500 SF back to the GSA by moving out of the entire first floor of Building 3 into existing USGS space on the campus such as Building 2, Building 11, and Building 15.

In 2016, the bureau will continue its progress toward accomplishing the savings targets set by Interior. The USGS will continue to fund the library consolidation projects at the Denver Federal Center and Menlo Park Campus, which will immediately reduce the space occupied by the library by 29,400 SF; a 48 percent reduction. Completing the Menlo Park library project will also speed up the overall consolidation plan at the Menlo Park Campus, which will ultimately release the remainder of Building 3; an additional reduction of 50,100 SF. The USGS will also continue to fund a co-location project with the Bureau of Reclamation, in Boulder City, NV. This project will significantly reduce the rent costs as well as lessen the Interior's overall footprint.

The USGS continues to work toward meeting the "energy and water conservation goals" set forth by E.O. 13423, "Strengthening Federal Environmental, Energy, and Transportation Management; the Energy Independence and Security Act of 2007 (EISA); and E.O. 13514, Federal Leadership in Environmental, Energy, and Economic Performance," and has implemented an energy management plan to guide programs toward meeting mandated goals. In 2014, the USGS exceeded its goals for achieving "water use reduction" and "renewable energy consumption" goals set forth in E.O. 13423. The USGS fell short

of the "energy use reduction" goals due to the severe winter experienced by the majority of our reporting science centers. The USGS awarded a large Energy Savings Performance Contract (ESPC) in 2014 to help the USGS meet future energy use-reduction goals.

In 2016, the USGS will continue utilizing the Interior's Financial and Business Management System (FBMS) to track all of its utility costs and consumption. This action ensures the Interior has a consistent methodology for collecting and reporting purposes.

The USGS continues to use industry standard cost modeling to project the appropriate sustainment level for operations and maintenance funding and to identify voids in critical cyclical and preventive maintenance practices and processes.

In compliance with the December 2, 2011, Presidential Memorandum, Implementation of Energy Savings Projects and Performance-Based Contracting for Energy Savings, and the December 3, 2013, Presidential Memorandum to utilize performance contacts to award $4 billion worth of energy and water saving projects throughout the Federal Government, the USGS ESPC project was awarded in the fourth quarter of 2014 for $12 million. The ESPC will reduce the USGS's energy consumption by 15 percent, potable water use by five percent, and its Scope 1&2 Greenhouse Gas emissions by nine percent. The ESPC will annually generate over $660,000 of savings, which will pay for the energy and water improvements.

In 2014, the Department of Energy awarded the USGS Great Lakes Science Center (GLSC) the 2014 Federal Energy and Water Management Project Award for its wet laboratory upgrade. Prior to the wet lab upgrade, almost all the original equipment was past its useful life and significant maintenance was required to maintain and operate the system. The project upgraded the distribution and discharge systems, changed the water supply from well water to city water, installed new PVC piping to reduce the risk of clogging, and drastically lowered the need for pumping energy. The system now operates as a re-circulating water system, conserving roughly 52.6 million gallons per year that were previously drawn from the local aquifer. Water is no longer discharged to the storm-water system, eliminating the need for a $9,000 annual discharge permit. The use of a recirculating system also reduced the operation of the facility's chillers, saving 350,000 kilowatt-hours of electricity per year and preventing the emission of greenhouse gases equal to the annual emissions of 51 cars. In 2013, the GLSC electricity consumption was 32 percent less than 2011 when the wet lab was last in full operation. Lastly, the new system provides at least 50 percent more capacity than the old, enabling the researchers to better fulfill their mission.

The USGS is working toward achieving the 2015 goal set forth by E.O. 13514, which requires 10 percent of the electric energy consumed by the USGS be generated from renewable energy sources. Additionally, the USGS has developed a plan to meet the 2020 goal set forth by the December 5, 2013, Presidential Memorandum, regarding Federal leadership on energy management, increasing this goal to 20 percent renewable energy sources for electrical power consumed.

In compliance with the Energy Independence and Security Act of 2007 (EISA), the USGS conducted energy and water evaluations at all of the required covered facilities, which constitutes 75 percent of the

total facility energy use for the USGS. The USGS also benchmarked the covered facilities in Energy Star portfolio Manager per EISA requirements.

In 2016, the USGS Facility Energy Program will continue to ensure that all facility managers understand the energy and water efficiency mandates and goals, and will provide guidance and assistance, as necessary. The program will promote alternative financing, renewable energy technologies, sustainable design principles in all projects, and training to ensure that field personnel have the tools necessary to meet the energy and water efficiency mandates.

In 2016, the USGS will continue to make every effort to ensure that when entering lease agreements, provisions that encourage energy and water efficiency are incorporated. Build-to-suit lease solicitations will contain criteria encouraging sustainable design and development, energy efficiency, and verification of building performance. In addition, a preference for buildings having the Energy Star building label will be included in the selection criteria for acquiring leased buildings, and leasing companies will be encouraged to apply for the Energy Star building label.

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Activity: Facilities

Subactivity: Deferred Maintenance and Capital Improvements

2014 Actual: $7.3 million (0 FTE)
2015 Enacted: $7.3 million (0 FTE)
2016 Request: $7.3 million (0 FTE)

Overview

Annually, the USGS develops a Deferred Maintenance and Capital Improvements (DMCI) five-year plan. The plan provides the projects of greatest need in priority order that best support bureau missions, with focus first on critical health and safety and critical resource protection. The bureau has undertaken an extensive effort in developing this plan, identifying projects where the urgency of remediation and science program impact are most visible.

The DMCI subactivity funds address the highest priority USGS facility and equipment needs according to Interior's guidance. The current funding level addresses approximately nine percent of the facilities deferred maintenance and capital improvements backlog of $82.2 million (as reported in the 2014 Federal Real Property Profile [FRPP]). The condition assessment program includes annual surveys and a cyclic process for comprehensive onsite inspections to document deferred maintenance.

Facilities projects reflect comprehensive evaluations conducted by independent architectural and engineering firms. These installation-wide assessments help establish core data on the condition of USGS constructed assets.

The condition assessment (CA) process identifies deferred maintenance needs and determines the current replacement value of constructed assets. Knowing the estimated cost of deferred maintenance and the replacement value of constructed assets allows the USGS to use the industry standard FCI as a method of measuring facility condition and condition changes. It is an indicator of the depleted value of capital assets. Funds are also available through the condition assessment process to identify, report, and track any asbestos, environmental, and disposal liability sites on departmental lands according to guidelines issued by the Interior's Office of Environmental Policy and Compliance.

Through the asset management planning process, the USGS can identify real property assets that are candidates for disposition. Any asset that is no longer critical to the mission, in poor condition, or no longer cost effective to maintain is a candidate for possible disposal.

The USGS has stewardship responsibility for unique mission equipment assets such as hazard warning networks, river cableways, and streamgaging stations, all of which require maintenance and capital investments to preserve their functionality. Projects targeting these assets are included under the Equipment Section of the DMCI five-year plan.

The USGS prioritizes critical DMCI needs according to the Interior's guidelines. Five-year plans are updated on an annual basis using the uniform, departmentwide process. Plans are subject to adjustments in outyears due to funding changes and revised priorities based on comprehensive facility condition assessments, annual condition surveys, and emergency needs. The goal of the five-year planning process is to focus limited resources on projects that are both mission critical and in the most need of repair or replacement. The ranking equation is designed to accommodate many types and sizes of projects, from simple to complex and places the highest priority on facility buildings based on their Facility Condition Index (FCI) and Asset Priority Index (API) ranking. This emphasizes projects that involve mission critical assets in unacceptable condition with less emphasis on non-mission critical assets. The average FCI for USGS owned building is 0.189 and the average FCI for USGS owned structures of 0.154. The USGS determines anything below a 0.15 score on an asset to be in the acceptable range of condition. The Interior's newly defined criteria for 2016 and methodology also takes into account—

- Projects that are clearly aligned with Interior, bureau, office and program missions, initiatives, and strategic goals.
- Projects that clearly define a positive return on investment, leverage outside interest, and reduce operation and maintenance liabilities.
- Projects that have unacceptable risk levels should the project not be completed.

Program Performance

Cableways have been used for many decades by the USGS for the measurement of streamflow and collection of water-quality samples. DMCI funds associated with the USGS Streamgaging Network provided the ability to upgrade vital cableways that needed to be restored to safe operation, and to remove abandoned cableways that present a potential hazard to public safety. In 2014, the USGS operated approximately 850 cableways. Properly constructed and maintained cableways are dependable and convenient platforms for obtaining water-resource data. The use of cableways eliminates the need for USGS personnel to work from dangerous highway bridges and allow the selection of sites that offer optimum hydraulic characteristics for measuring stream discharge. Cableways consisting of a main cable, anchors, support structures, backstays, cablecars, and other equipment are subject to damage and deterioration from temperature changes, moisture, and vandalism. The integrity of the structure may also be threatened by erosion as a result of overland runoff or by flooding. Because of this, cableways are carefully monitored on a continuing basis and those that do not meet safety standards are removed from service until all defects are corrected and approved for use by USGS personnel. The Water Resources Mission Area (WRMA) determined that certain cableways might possibly pose a risk to low-flying aircraft and should be retrofitted with aircraft warning markers. To minimize safety hazards, USGS policy states that intact overhead cables are to be removed from inactive cableways as soon as possible. In 2014, 10 major cableway projects were completed; 72 cableways are inactive and awaiting repair, 51 cableways have been abandoned and are awaiting removal. In 2015-2016, 57 projects are planned for the renovation and removal of abandoned cableways at multiple locations nationwide. DMCI equipment funding also provided some upgrading of seismic instrumentation to the Earthquake Monitoring Project (EMP), extending the life of older dataloggers for many more years and capitalizing on the extensive USGS investment in the seismic equipment. In 2014, DMCI equipment funds were provided to the

National Strong Motion Project (NSMP) to upgraded three analog stations. In 2015, seven more are planned; 230 analog stations are pending upgrades.

The Facility Maintenance Management System (FMMS) is the USGS's implementation of the commercial maintenance-management software application Maximo™. The FMMS system supports efficient operation and maintenance of USGS facilities by providing accurate maintenance information to local, regional, and national facility managers. It is used to document maintenance needs and accomplishments, preventive maintenance schedules, and the condition of USGS real property assets. The system is also used in the development of the USGS Deferred Maintenance and Capital Improvement (DMCI) five-year plan. Condition assessments results, which often are the basis for DMCI projects, are automatically imported in FMMS, which provide an automated repository of deficiency findings and the actions taken to address them. Use of the FMMS supports the USGS's Asset Management Plan by establishing an inventory and maintenance history on all constructed assets and associated equipment, standardizing maintenance business practices, facilitating maintenance reporting and data analysis, and supporting the budget and the DMCI five-year planning processes.

The FMMS includes a mobile work order component, used by maintenance technicians at larger centers, to document maintenance requests and day-to-day maintenance activities in the field. In 2015 a new "smart device" based mobile work order management application will be implemented to leverage bureau investments in smart technology and provide FMMS users with a more modern, flexible mobile platform.

The USGS plays a significant role in the Interior's Maximo Upgrade project by providing technical expertise to the project team. This National Park Service-led project will assist bureaus in upgrading to the latest Maximo version and establishing a baseline for future system consolidation. The USGS has scheduled the upgraded version for deployment in 2015. Concurrent with the software upgrade, the Interior has established a Maximo Special Interest Group (SIG) to facilitate best practices and standardization of business processes among the bureaus. The USGS is also lending Maximo technical expertise to this effort as well as being an active participant in the SIG.

In 2014, six DMCI projects were completed at a total cost of $2.7 million. Included in these projects were the replacement of the Sewage Treatment Facility at the Leetown Science Center; the rooftop heat and air conditioning replacement on Fish Passage Building at S.O. Conte; the Main Building at the National Wildlife Health Center (NWHC) had the necropsy space renovated for histology and also replaced the emergency generator, and the emergency generator was also replaced in Tight Isolation Building at the NWHC. In addition, the Veterinarian Hospital at the Patuxent Wildlife Research Center (PWRC) was rehabilitated.

2016 Deferred Maintenance and Capital Improvements Plan

The following table lists, in priority order, the proposed projects and equipment to be addressed by DMCI in 2016, within available funding. ($000)

Facility or Project Name/Project Amount	Project Number/Description
Cost Savings and Innovation Plan (CSIP) $2,225*	Denver Federal Center - CSIP - Reduce the Footprint Project # CSIP FY16
Hammond Bay Biological Station (HBBS) $2,964	Phase 2 of Modernization of Laboratory Project # 1923914 (Phase 1 funded in FY 2015)
Earth Resources Observation and Science Data Center (EROS) $386	Remodel restrooms – replace plumbing fixtures, faucets and flush valves to meet Americans with Disabilities Act (ADA) Project # 1842812
Earth Resources Observation and Science Data Center (EROS) $44	Preventative Maintenance on 15 KV electrical switches. Project # 1759506
Earth Resources Observation and Science Data Center (EROS) $254	Replacement of six fire control panels (in the portion of the Mundt Federal Building built in 1973) and smoke detectors throughout the entire building. Project # 2103425
Southeast Ecological Science Center (SESC) $65	Remove the old fiberglass roofing panels and replace with new; old panels to be recycled. Project # 2254147
National Wetlands Research Center (NWRC) $34	Reconstruct front door assembly to comply with American Disabilities Act (ADA) Project # 2445650

* Since 2012, the USGS has been funding its CSIP projects from the DMCI subactivity. The proposed increase would allow the USGS to restore the $2.225 million in DMCI funding currently being used to fund CSIP projects. DMCI projects planned for 2017 would be moved up to 2016.

2016 Equipment Projects

Project Name/Project Amount	Project Description
113 Sites Nationwide $240	Repair, Replace, or Remove Cableways (W1998A10000): 840 Cableways are Active and in Use Nationwide
Northern California Seismic Network $200	Replace Network Analog and Microwave Stations (G987160001): Replace Earthquake Network Stations providing seismic monitoring and warning for large Metropolitan areas.
Condition Assessments (CA) $210	Condition Assessments (CA)/Engineering Support: Complete CA's for the identification of maintenance and capital improvement needs, Provide engineering services support for funded projects, and Conduct Surveys to determine asbestos-related cleanup, environmental and disposal cost.
Federal Maintenance Management System (FMMS) $350	Federal Maintenance Management System (FMMS): Implement and maintain a Maintenance Management System that meets bureau reporting and oversight requirements.
Program and Project Management Support $308	Project Planning: Contract architectural, engineering, management and design services for complex projects, particularly for developing project requirements and cost estimates.

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Working Capital Fund

Working Capital Fund Overview

The U.S. Geological Survey (USGS) Working Capital Fund (WCF) was established to allow for the efficient financial management of the components listed below. The WCF was made available for expenses necessary for furnishing materials, supplies, equipment, work, and services in support of USGS programs, and as authorized by law (authorization information begins on page 3 of this section), to agencies of the Federal Government and others. The WCF consists of four components:

1. The WCF **Investment** Component provides a mechanism to assist USGS managers in planning for and acquiring goods and services that are too costly to acquire in a single fiscal year or that, due to the nature of services provided must operate in a multi- as opposed to a single-year basis of funding. Investments are supported by documented investment plans that include estimated acquisition/replacement costs, a schedule of deposits, and approval of the plans, deposits and expenditures by designated USGS officials.

- **Telecommunications Investments** are used for telecommunication hardware, software, facilities, and services. Examples include replacement or expansion of automatic exchange systems and computerized network equipment such as switches, routers, and monitoring systems.
- **Equipment Investments** are used for the acquisition, replacement, and expansion of equipment for USGS programs. Equipment may include, but is not limited to, hydrologic, geologic, and cartographic instruments, laboratory equipment, and computer hardware and software.
- **Facilities Investments** support facility and space management investment expenses for USGS real property, including owned and leased space. Authorized investment expenses include nonrecurring and emergency repair, relocation of a facility, and facility modernization. The component does not include annual expenses such as rent, day-to-day operating expenses, recurring maintenance, or utilities.
- **Publications Investments** are used for the preparation and production of technical publications reporting on the results of scientific data and research. Research projects typically are three to five years in duration, and planning the medium in which to report results occurs over the life of the project. The Publications Investment Component provides a mechanism for establishing an efficient, effective, and economical means of funding publications costs over the duration of the research.

2. The WCF **Fee-for-Service** Component provides a continuous cycle of client services for fees established in a rate-setting process and, in some cases, with funding provided by appropriated funds. Fees are predicated upon both direct and indirect costs associated with providing the services, including amortization of equipment required to provide the services.

- **The National Water Quality Laboratory (NWQL)** conducts chemical and biological analyses of water, sediments, and aquatic tissue for all USGS science centers and other customers, including other USGS mission areas, other Interior Bureaus, and non-USGS

customers. The NWQL also does biological classification for these customers. NWQL analysis services are provided on a reimbursable basis, with the price of services calculated to cover direct and indirect costs.

- **The USGS Hydrologic Instrumentation Facility (HIF)** provides hydrologic instrumentation on a fee-for-service basis. The facility provides its customers with hydrologic instruments that can be rented or purchased, maintains a technical expertise on instrumentation, and tests and evaluates new technologies as they become available in the marketplace.
- **Bureau Laboratories –** There are currently five laboratories within the Water Resources Mission Area that perform gaseous dissolved chlorofluorocarbon measurements, environmental microbiology analyses and isotope-ratio measurements of water, sediments, rocks, and gases for all USGS mission areas, and for USGS customers.
- **The National Training Center** conducts USGS training programs. Examples include specialized training for USGS employees, cooperators, and international participants in many facets of earth science, as well as computer applications, management and leadership seminars, and various workshops.
- **Research Drilling Program –** The Drilling Program is operated out of two locations, Lakewood, CO, and Las Vegas, NV. The Central Region Research Drilling Project and Western Research Drilling Operation were merged to create one Research Drilling Program in 2014. The Drilling Program provides drilling and drilling related services to research projects across the United States. These services include conducting exploratory drilling and obtaining geologic samples and cores in difficult hydrogeologic environments, installation of sampling devices, monitoring wells and other sub-surface sensors, borehole geophysical logging, and well and aquifer hydraulic testing support.

3. The GSA **Buildings Delegation** Component is used to manage funds received under the delegated authority for the J.W. Powell Building and Advanced Systems Center in Reston, VA, as provided by 40 U.S.C. 121 (d) and (e) (formerly subsections 205 (d) and (e) of the Federal Property and Administrative Services Act of 1949, as amended, and 40 U.S.C. 486 (d) and (e), respectively). Delegated functions include building operations, maintenance, cleaning, overseeing fire and life safety, maintaining high voltage switchgear and fire alarms, recurring repairs, minor alterations, historic preservation, concessions, and energy management. Because of the size of the Reston buildings and the need to expend the facility funds in a manner corresponding to GSA's no-year funding (Federal Buildings Fund) mechanisms and the GSA National Capital Region long-range capital improvement plan, no-year funding is a prerequisite to administering the delegation. Public Law 104–208, Section 611, provides that, for the fiscal year ending September 30, 1997, and thereafter, any department or agency that has delegated authority shall retain that portion of the GSA rental payment available for operation, maintenance, and repair of the building and the funds shall remain available until expended. This WCF component was established in 2004 to provide USGS with this no-year flexibility.

4. The **Enterprise Services** Component operates in a businesslike manner, recovering fees for various consolidated services provided to USGS mission areas and other Federal agencies. By leveraging

these services through a unified effort, USGS achieves cost and business efficiencies that would otherwise be lost.

The Science Publishing Network (SPN) operates within the Enterprise Services Component of the WCF. The SPN provides high quality publishing support for science information products while improving its operational effectiveness and efficiencies. The SPN offers a wide range of publishing services to authors of USGS information products and others. Services include consultation, technical editing, illustrating, layout and design, Web services, printing management and distribution, electronic publishing as well as other publishing needs.

Appropriation Language and Citations

Permanent authority:

1. Provided further, That, in fiscal year 1986, and thereafter, all amortization fees resulting from the Geological Survey providing telecommunications services shall be deposited in a special fund to be established on the books of the Treasury and be immediately available for payment of replacement or expansion of telecommunications services, to remain available until expended.

    - **43 U.S.C.50a** established the Telecommunications Amortization Fund, which was displayed as part of the Surveys, Investigations and Research appropriation from 1986 through 1990. Beginning in 1991, the Telecommunications Amortization Fund was merged into the WCF described in the next citation.

2. There is hereby established in the Treasury of the United States a working capital fund to assist in the management of certain support activities of the United States Geological Survey (hereafter referred to as the "Survey"), Department of the Interior. The fund shall be available on and after November 5, 1990, without fiscal year limitation for expenses necessary for furnishing materials, supplies, equipment, work, facilities, and services in support of Survey programs, and, as authorized by law, to agencies of the Federal Government and others. Such expenses may include laboratory modernization and equipment replacement, computer operations, maintenance, and telecommunications services; requirements definition, systems analysis, and design services; acquisition or development of software; systems support services such as implementation assistance, training, and maintenance; acquisition and replacement of computer, publications and scientific instrumentation, telecommunications, and related automatic data processing equipment; and, such other activities as may be approved by the Secretary of the Interior.

    There are authorized to be transferred to the fund, at fair and reasonable values at the time of transfer, inventories, equipment, receivables, and other assets, less liabilities, related to the functions to be financed by the fund as determined by the Secretary of the Interior. Provided, That the fund shall be credited with appropriations and other funds of the Survey, and other agencies of the Department of the Interior, other Federal agencies, and other sources, for providing materials, supplies, equipment, work, and other services as authorized by law and such payments may be made in advance or upon performance: Provided further, That charges to users will be at rates approximately equal to the costs of furnishing the materials, supplies, equipment, facilities, and services, including such items as depreciation of equipment and facilities, and accrued annual leave: Provided further, That all existing balances as of November 5, 1990, from amortization fees resulting from the Survey providing telecommunications services and deposited in a special fund established on the books of the Treasury and available for payment of replacement or expansion of telecommunications services as authorized by Public Law 99-190, are hereby transferred to and merged with the working capital fund, to be used for the same purposes as originally authorized. Provided further, That funds that are not necessary to carry out the activities to be financed by the fund, as determined by the Secretary, shall be covered into miscellaneous receipts of the Treasury.

P.L. 101-512 Department of the Interior and Related Agencies Appropriations Act, 1991 This authority established a Working Capital Fund account in 1991. The Telecommunications Amortization Fund was included as part of the WCF and all balances of the Telecommunications Amortization Fund existing at the end of 1990 were transferred to the WCF. These balances were to be used for the same purposes as originally authorized.

P.L. 103-332 Department of the Interior and Related Agencies Appropriations Act, 1995 The amendments that were made in this appropriations act are shown in underline in the second citation shown above. This authority expanded the use of the Working Capital Fund to partially fund laboratory operations and facilities improvements and to acquire and replace publication and scientific instrumentation and laboratory equipment.

United States Geological Survey

Federal Funds

General and special funds:

WORKING CAPITAL FUND

Program and Financing

(In millions of dollars)

Identification Code 14-4556-0-4-306		2014 Actual	2015 Enacted	2016 Request
	Obligations by program activity:			
08.01	Working Capital Fund	82	87	82
	Budgetary resources:			
	Unobligated balance:			
10.00	Unobligated balance carried forward, start of year	75	86	80
10.21	Recoveries of prior year unpaid obligations	2		
10.50	Unobligated balance total	77	86	80
	Budget Authority:			
	Spending Authority from offsetting collections, disc			
17.00	Collected	91	81	81
19.30	Total budgetary resources available	168	167	161
	Memorandum (non-add) entries:			
19.41	Unexpired unobligated balance, end of year	86	80	79
	Change in obligated balances:			
	Obligated balance, start of year:			
30.00	Unpaid obligations, brought forward, Oct 1	33	25	32
30.10	Obligations incurred, unexpired accounts	82	87	82
30.20	Outlays, Gross	-88	-80	-78
30.40	Recoveries of prior year obligations	-2	0	0
	Obligated balance, end of year:			
30.50	Unpaid Obligations, end of year (gross)	25	32	36
	Budget authority and outlays, net:			
	Discretionary			
40.00	Budget authority, gross	91	81	81
	Outlays, gross:			
40.10	Outlays from new discretionary authority	13	36	36
40.11	Outlays from discretionary balances	75	44	42
40.20	Outlays, gross	88	80	78
	Offsets against gross budget authority and outlays:			
	Offsetting collections (collected) from:			
40.30	Federal Sources	-91	-81	-81
40.70	Budget authority, net (discretionary)			
40.80	Outlays, net (discretionary)	-3	-1	-3
41.80	Budget authority, net (total)			
41.90	Outlays, net (total)	-3	-1	-3

WORKING CAPITAL FUND

Balance Sheet

(In millions of dollars)

Identification Code 14-4556-0-4-306		2013 Actual	2014 Actual
	ASSETS:		
	Federal assets:		
1101	Fund balances with Treasury	108	111
	Investments in U.S. securities:		
1106	Receivables, net		
1803	Other Federal assets: Property, plant and equipment, net	26	34
1999	Total assets	134	145
	LIABILITIES:		
2101	Federal liabilities: Accounts payable		
2201	Non-Federal liabilities: Accounts payable	5	4
2999	Total liabilities	5	4
	NET POSITION:		
3300	Cumulative results of operations	129	141
3999	Total net position	129	141
4999	Total liabilities and net position	134	145

WORKING CAPITAL FUND

Object Classification

(In millions of dollars)

Identification Code 14-4556-0-4-306		2014 Actual	2015 Enacted	2016 Request
	Reimbursable obligations:			
	Personnel compensation:			
11.1	Full-time permanent	17	17	17
11.3	Other than full-time permanent	1	1	1
11.5	Other personnel compensation	1	1	1
11.9	Total personnel compensation	19	19	19
12.1	Civilian personnel benefits	5	5	5
21.0	Travel and transportation of persons	1	0	0
23.1	Rental payments to GSA	1	1	1
23.3	Communications, utilities, and miscellaneous charges	2	1	1
24.0	Printing and reproduction	1	1	0
25.2	Other services	10	8	8
25.3	Other purchases of goods and services from Government Accounts	6	9	6
25.4	Operation and maintenance of facilities	6	10	9
25.7	Operation and maintenance of equipment	2	3	3
26.0	Supplies and materials	4	2	2
31.0	Equipment	24	27	27
32.0	Land and structures	1	1	1
99.9	Total new obligations	82	87	82

WORKING CAPITAL FUND

Employment Summary

Identification Code 14-4556-0-4-306		2014 Actual	2015 Enacted	2016 Request
	Reimbursable:			
2001	Civilian full-time equivalent employment	229	229	229

Account Exhibits

SURVEYS, INVESTIGATIONS, AND RESEARCH

Summary of Requirements by Object Class

(Millions of Dollars)

Appropriation: Surveys, Investigations, and Research		**2015 Enacted**		**Fixed Costs**		**Program Changes**		**2016 Request**	
Object Class		**FTE**	**Amount**	**FTE**	**Amount**	**FTE**	**Amount**	**FTE**	**Amount**
	Personnel compensation								
11.1	Full-time permanent		407		8		13		428
11.3	Other than full-time permanent		37		0		2		39
11.5	Other personnel compensation		11		0		0		11
	Total personnel compensation	4,935	455	0	8	207	15	5,142	478
12.1	Civilian personnel benefits		135		2		4		141
13.0	Benefits for former personnel		1		0		0		1
21.0	Travel and transportation of persons		17		0		0		17
22.0	Transportation of things		1		0		0		1
23.1	Rental payment to GSA		58		-2		0		56
23.2	Rental payments to others		3		0		0		3
23.3	Comm., utilities and misc. charges		17		0		0		17
24.0	Printing and reproduction		1		0		0		1
25.1	Advisory and assistance services		9		0		0		9
25.2	Other services from non-Fed sources		104		1		122		227
25.3	Other goods and services from Fed sources		75		0		0		75
25.4	Operation and maintenance of facilities		17		0		0		17
25.5	Research and development contracts		3		0		0		3
25.7	Operation and maintenance of equipment		21		0		0		21
26.0	Supplies and materials		19		0		0		19
31.0	Equipment		34		0		0		34
32.0	Land and structures		1		0		0		1
41.0	Grants, subsidies, and contributions		74		0		0		74
	Total requirements		**1,045**		**9**		**141**		**1,195**

This information is displayed in budget authority (not obligations) by object class.

SURVEYS, INVESTIGATIONS, AND RESEARCH

Summary of Requirements by Object Class

(Millions of Dollars)

Appropriation: Surveys, Investigations, and Research							
		2015 Enacted		**2016 Request**		**Increase or Decrease**	
Reimbursable Obligations		**FTE**	**Amount**	**FTE**	**Amount**	**FTE**	**Amount**
	Personnel compensation						
11.1	Full-time permanent		159		159		0
11.3	Other than full-time permanent		30		30		0
11.5	Other personnel compensation		4		4		0
	Total personnel compensation	2,687	193	2,687	193	0	0
12.1	Civilian personnel benefits		59		59		0
13.0	Benefits for former personnel		1		1		0
21.0	Travel and transportation of persons		11		11		0
22.0	Transportation of things		1		1		0
23.1	Rental payments to GSA		19		19		0
23.2	Rental payments to others		1		1		0
23.3	Communications, utilities and miscellaneous Charges		8		8		0
25.1	Advisory and assistance services		4		4		0
25.2	Other services		51		51		0
25.3	Other purchases of goods and services from Government accounts		29		29		0
25.4	Operation and maintenance of facilities		10		10		0
25.7	Operation and maintenance of equipment		6		6		0
26.0	Supplies and materials		12		12		0
31.0	Equipment		18		18		0
41.0	Grants, subsidies, and contributions		28		28		0
	Total requirements		**451**		**451**		**0**

United States Geological Survey

Federal Funds

General and special funds:

SURVEYS, INVESTIGATIONS, AND RESEARCH

Program and Financing

(Millions of Dollars)

Identification Code 14-0804-0-1-306		2014 Actual	2015 Enacted	2016 Estimate
	Obligations by program activity:			
00.01	Ecosystems	154	157	176
00.02	Climate and Land Use Change	131	137	187
00.03	Energy, Minerals, and Environmental Health	91	93	103
00.04	Natural Hazards	128	135	155
00.05	Water Resources	208	210	222
00.06	Core Science Systems	110	108	126
00.07	Science Support	108	108	113
00.08	Facilities	107	104	114
07.99	Total direct obligations	1,037	1,052	1,196
08.01	Reimbursable program	451	451	451
09.00	Total new obligations	1,488	1,503	1,647
	Budgetary resources:			
	Unobligated balance:			
10.00	Unobligated balance brought forward, Oct 1	404	433	462
10.21	Recoveries of prior year unpaid obligations	9	0	0
10.50	Unobligated balance (total)	413	433	462
	Budget authority:			
	Appropriations, discretionary:			
11.00	Appropriation	1,032	1,045	1,195
11.60	Appropriation, discretionary (total)	1,032	1,045	1,195
	Appropriations, mandatory:			
12.21	Appropriations transferred from other accts, Spectrum Relocation Fund [011-5512]	0	36	0
12.60	Appropriation, mandatory (total)	0	36	0
	Spending authority from offsetting collections, discretionary:			
17.00	Collected	418	451	451
17.01	Change in uncollected payments, Federal sources	58	0	0
17.50	Spending auth from offsetting collections, disc (total)	476	451	451
19.00	Budget authority (total)	1,508	1,532	1,646
19.30	Total budgetary resources available	1,921	1,965	2,108

SURVEYS, INVESTIGATIONS, AND RESEARCH

Program and Financing cont'd

(Millions of Dollars)

Identification Code 14-0804-0-1-306		2014 Actual	2015 Enacted	2016 Estimate
	Memorandum (non-add) entries:			
19.41	Unexpired unobligated balance, end of year	433	462	461
	Change in obligated balance:			
	Unpaid obligations:			
30.00	Unpaid obligations, brought forward, Oct 1	340	332	280
30.10	Obligations incurred, unexpired accounts	1,488	1,503	1,647
30.11	Obligations incurred, expired accounts	2	0	0
30.20	Outlays (gross)	-1,484	-1,555	-1,672
30.40	Recoveries of prior year unpaid obligations, unexpired	-9	0	0
30.41	Recoveries of prior year unpaid obligations, expired	-5	0	0
30.50	Unpaid obligations, end of year	332	280	255
	Uncollected payments:			
30.60	Uncollected payments, Fed sources, brought forward, Oct 1	-455	-496	-496
30.70	Change in uncollected payments, Fed sources, unexpired	-58	0	0
30.71	Change in uncollected payments, Fed sources, expired	17	0	0
30.90	Uncollected payments, Fed sources, end of year	-496	-496	-496
	Memorandum (non-add) entries:			
31.00	Obligated balance, start of year	-115	-164	-216
32.00	Obligated balance, end of year	-164	-216	-241
	Budget authority and outlays, net:			
	Discretionary:			
40.00	Budget authority, gross	1,508	1,496	1,646
	Outlays, gross:			
40.10	Outlays from new discretionary authority	865	1,317	1,449
40.11	Outlays from discretionary balances	619	237	213
40.20	Outlays, gross (total)	1,484	1,554	1,662
	Offsets against gross budget authority and outlays:			
	Offsetting collections (collected) from:			
40.30	Federal sources	-232	-239	-239
40.33	Non-Federal sources	-203	-212	-212
40.40	Offsets against gross budget authority and outlays (total)	-435	-451	-451

SURVEYS, INVESTIGATIONS, AND RESEARCH

Program and Financing cont'd

(Millions of Dollars)

Identification Code 14-0804-0-1-306		2014 Actual	2015 Enacted	2016 Estimate
	Additional offsets against gross budget authority only:			
40.50	Change in uncollected payments, Fed sources, unexpired	-58	0	0
40.52	Offsetting collections credited to expired accounts	17	0	0
40.60	Additional offsets against budget authority only (total)	-41	0	0
40.70	Budget authority, net (discretionary)	1,032	1,045	1,195
40.80	Outlays, net (discretionary)	1,049	1,103	1,211
	Mandatory:			
40.90	Budget authority, gross	0	36	0
	Outlays, gross:			
41.00	Outlays from new mandatory authority	0	1	0
41.01	Outlays from mandatory balances	0	0	10
41.10	Outlays, gross (total)	0	1	10
41.80	Budget authority, net (total)	1,032	1,081	1,195
41.90	Outlays, net (total)	1,049	1,104	1,221

SURVEYS, INVESTIGATIONS, AND RESEARCH

Object Classification

(Millions of Dollars)

Identification Code 14-0804-0-1-306		2014 Actual	2015 Enacted	2016 Estimate
	Direct obligations:			
	Personnel compensation:			
11.1	Full-time permanent	407	407	429
11.3	Other than full-time permanent	37	37	39
11.5	Other personnel compensation	11	11	11
11.9	Total personnel compensation	455	455	479
12.1	Civilian personnel benefits	135	135	141
13.0	Benefits for former personnel	1	1	1
21.0	Travel and transportation of persons	17	17	17
22.0	Transportation of things	1	1	1
23.1	Rental payments to GSA	57	58	56
23.2	Rental payment to others	3	3	3
23.3	Comm., utilities, and miscellaneous charges	17	17	17
24.0	Printing and reproduction	1	1	1
25.1	Advisory and assistance services	9	9	14
25.2	Other services from non-Fed sources	97	111	218
25.3	Other goods and services from Fed sources	75	75	75
25.4	Operation and maintenance of facilities	17	17	17
25.5	Research and development contracts	3	3	3
25.7	Operation and maintenance of equipment	21	21	21
26.0	Supplies and materials	19	19	19
31.0	Equipment	34	34	38
32.0	Land and structures	1	1	1
41.0	Grants, subsidies, and contributions	74	74	74
99.0	Direct obligations	1,037	1,052	1,196

SURVEYS, INVESTIGATIONS, AND RESEARCH

Object Classification cont'd

(Millions of Dollars)

Identification Code 14-0804-0-1-306		2014 Actual	2015 Enacted	2016 Estimate
	Reimbursable obligations:			
	Personnel compensation:			
11.1	Full-time permanent	159	159	159
11.3	Other than full-time permanent	30	30	30
11.5	Other personnel compensation	4	4	4
11.9	Total personnel compensation	193	193	193
12.1	Civilian personnel benefits	59	59	59
13.0	Benefits for former personnel	1	1	1
21.0	Travel and transportation of persons	11	11	11
22.0	Transportation of things	1	1	1
23.1	Rental payments to GSA	19	19	19
23.2	Rental payments to others	1	1	1
23.3	Comm., utilities, and miscellaneous charges	8	8	8
25.1	Advisory and assistance services	4	4	4
25.2	Other services from non-Fed sources	51	51	51
25.3	Other goods and services from Fed sources	29	29	29
25.4	Operation and maintenance of facilities	10	10	10
25.7	Operation and maintenance of equipment	6	6	6
26.0	Supplies and materials	12	12	12
31.0	Equipment	18	18	18
41.0	Grants, subsidies, and contributions	28	28	28
99.0	Reimbursable obligations	451	451	451
99.9	Total new obligations	1,488	1,503	1,647

SURVEYS, INVESTIGATIONS, AND RESEARCH

Employment Summary

Identification Code 14-0804-0-1-306		2014 Actual	2015 Enacted	2016 Estimate
	Direct:			
1001	Civilian full-time equivalent employment	4,982	4,935	5,142
	Reimbursable:			
2001	Civilian full-time equivalent employment	2,687	2,687	2,687
	Allocation account:			
3001	Civilian full-time equivalent employment	71	71	71

Sundry Exhibits

Funding of U.S. Geological Survey Programs (Obligations)

(Thousands of Dollars)

	2014 Actual	2015 Enacted	2016 Estimate
Surveys, Investigations, and Research (SIR)			
Ecosystems			
Appropriated			
Multi-Year appropriation	154,019	157,273	175,336
Total (appropriated)	**154,019**	**157,273**	**175,336**
Reimbursements			
Non-Federal (Domestic) sources			
Technology Transfer	2,860	2,860	2,860
Miscellaneous	8,305	8,305	8,305
Subtotal (non-Federal domestic sources)	11,165	11,165	11,165
State and local sources			
States-Coop (matched - In-Kind Services) NON ADD	542	542	542
States-Coop (unmatched)	1,245	1,245	1,245
Subtotal (state and local sources)	1,245	1,245	1,245
Federal sources			
Department of Agriculture	1,841	1,841	1,841
Department of Commerce			
Nat'l Oceanic & Atmospheric Admin	372	372	372
Department of Defense			
Corps of Engineers	19,517	19,517	19,517
Other	3,981	3,981	3,981
Department of Energy			
Bonneville Power Administration	1,864	1,864	1,864
Department of Homeland Security	178	178	178
Department of Interior			
Bureau of Land Management	5,863	5,863	5,863
Bureau of Ocean Energy Management	1,487	1,487	1,487
Bureau of Reclamation	12,417	12,417	12,417
Fish and Wildlife Service	9,633	9,633	9,633
National Park Service	1,977	1,977	1,977
Office of Secretary			
National Business Center	1,543	1,543	1,543
Department of State	283	283	283
Environmental Protection Agency	289	289	289
Health and Human Services	155	155	155
National Aeronautics & Space Admin	467	467	467
Subtotal (Federal sources)	61,867	61,867	61,867
Total (reimbursements)	**74,277**	**74,277**	**74,277**
Total: Ecosystems	**228,296**	**231,550**	**249,613**

	2014 Actual	2015 Enacted	2016 Estimate
Surveys, Investigations, and Research (SIR)			
Ecosystems			
Appropriated			
Multi-Year appropriation	154,019	157,273	175,336
Total (appropriated)	**154,019**	**157,273**	**175,336**
Reimbursements			
Non-Federal (Domestic) sources			
Technology Transfer	2,860	2,860	2,860
Miscellaneous	8,305	8,305	8,305
Subtotal (non-Federal domestic sources)	11,165	11,165	11,165
State and local sources			
States-Coop (matched - In-Kind Services) NON ADD	542	542	542
States-Coop (unmatched)	1,245	1,245	1,245
Subtotal (state and local sources)	1,245	1,245	1,245
Federal sources			
Department of Agriculture	1,841	1,841	1,841
Department of Commerce			
Nat'l Oceanic & Atmospheric Admin	372	372	372
Department of Defense			
Corps of Engineers	19,517	19,517	19,517
Other	3,981	3,981	3,981
Department of Energy			
Bonneville Power Administration	1,864	1,864	1,864
Department of Homeland Security	178	178	178
Department of Interior			
Bureau of Land Management	5,863	5,863	5,863
Bureau of Ocean Energy Management	1,487	1,487	1,487
Bureau of Reclamation	12,417	12,417	12,417
Fish and Wildlife Service	9,633	9,633	9,633
National Park Service	1,977	1,977	1,977
Office of Secretary			
National Business Center	1,543	1,543	1,543
Department of State	283	283	283
Environmental Protection Agency	289	289	289
Health and Human Services	155	155	155
National Aeronautics & Space Admin	467	467	467
Subtotal (Federal sources)	61,867	61,867	61,867
Total (reimbursements)	**74,277**	**74,277**	**74,277**
Total: Ecosystems	**228,296**	**231,550**	**249,613**

	2014 Actual	2015 Enacted	2016 Estimate
Surveys, Investigations, and Research (SIR)			
Climate and Land Use Change			
Appropriated			
Multi-Year appropriation	78,262	82,945	112,613
No-Year appropriation	52,443	53,665	74,637
Total (appropriated)	**130,705**	**136,610**	**187,250**
Reimbursements			
Non-Federal (Domestic) sources			
Technology Transfer	28	28	28
Miscellaneous	215	215	215
Subtotal (non-Federal domestic sources)	243	243	243
Non-Federal (Foreign) sources			
Corporacion Andina de Fomento	359	359	359
Miscellaneous	795	795	795
Subtotal (non-Federal Foreign sources)	1,154	1,154	1,154
Federal sources			
Agency for International Development	5,404	5,404	5,404
Central Intelligence Agency	803	803	803
Department of Agriculture	865	865	865
Department of Commerce			
Nat'l Oceanic & Atmospheric Admin	71	71	71
Department of Defense			
Corps of Engineers	198	198	198
Other	1,193	1,193	1,193
Department of Energy			
Bonneville Power Administration	118	118	118
Department of Homeland Security	58	58	58
Department of Interior			
Bureau of Indian Affairs	66	66	66
Bureau of Land Management	805	805	805
Bureau of Reclamation	40	40	40
Fish and Wildlife Service	280	280	280
National Park Service	478	478	478
Office of Secretary			
National Business Center	3,184	3,184	3,184
Environmental Protection Agency	1,159	1,159	1,159
Health and Human Services	95	95	95
National Aeronautics & Space Admin	11,128	11,128	11,128
Sale of maps, photos, reproductions, & digital products	344	344	344
Subtotal (Federal sources)	26,289	26,289	26,289
Total (reimbursements)	**27,686**	**27,686**	**27,686**
Total: Climate and Land Use Change	**158,391**	**164,296**	**214,936**

	2014 Actual	2015 Enacted	2016 Estimate
Surveys, Investigations, and Research (SIR)			
Energy, Minerals, and Environmental Health			
Appropriated			
Multi-Year appropriation	90,542	92,869	102,751
Total (appropriated)	**90,798**	**93,135**	**102,751**
Reimbursements			
Non-Federal (Domestic) sources			
Technology Transfer	1,575	1,575	1,575
Miscellaneous	715	715	715
Subtotal (non-Federal domestic sources)	2,290	2,290	2,290
Non-Federal (Foreign) sources			
Miscellaneous	60	60	60
Subtotal (non-Federal Foreign sources)	60	60	60
State and local sources			
States-Coop (matched - In-Kind Services) NON ADD	158	158	158
States-Coop (unmatched)	47	47	47
Subtotal (state and local sources)	47	47	47
Federal sources			
Department of Agriculture	211	211	211
Department of Commerce			
Nat'l Oceanic & Atmospheric Admin	33	33	33
Department of Defense			
Corps of Engineers	1	1	1
Other	6,627	6,627	6,627
Department of Energy			
Bonneville Power Administration	13	13	13
Department of Interior			
Bureau of Indian Affairs	33	33	33
Bureau of Land Management	1,224	1,224	1,224
Bureau of Reclamation	84	84	84
Fish and Wildlife Service	1,037	1,037	1,037
National Park Service	69	69	69
Office of Secretary			
National Business Center	60	60	60
Department of State	205	205	205
Environmental Protection Agency	413	413	413
Health and Human Services	16	16	16
National Aeronautics & Space Admin	402	402	402
National Science Foundation	9	9	9
Subtotal (Federal sources)	10,437	10,437	10,437
Total (reimbursements)	**12,834**	**12,834**	**12,834**
Total: Energy, Minerals, and Environmental Health	**103,632**	**105,969**	**115,585**

	2014 Actual	2015 Enacted	2016 Estimate
Surveys, Investigations, and Research (SIR)			
Natural Hazards			
Appropriated			
Multi-Year appropriation	127,830	134,959	145,794
Total (appropriated)	**127,830**	**134,959**	**145,794**
Reimbursements			
Non-Federal (Domestic) sources			
Technology Transfer	1,476	1,476	1,476
Miscellaneous	2,348	2,348	2,348
Subtotal (non-Federal domestic sources)	3,824	3,824	3,824
Non-Federal (Foreign) sources			
Saudi Geological Survey	1,141	1,141	1,141
Miscellaneous	15	15	15
Subtotal (non-Federal Foreign sources)	1,156	1,156	1,156
State and local sources			
States-Coop (unmatched)	454	454	454
Subtotal (state and local sources)	454	454	454
Federal sources			
Agency for International Development	4,054	4,054	4,054
Department of Commerce			
Nat'l Oceanic & Atmospheric Admin	149	149	149
Department of Defense			
Corps of Engineers	1,037	1,037	1,037
Other	1,030	1,030	1,030
Department of Energy			
Bonneville Power Administration	1,053	1,053	1,053
Department of Homeland Security	272	272	272
Department of Interior			
Bureau of Ocean Energy Management	182	182	182
Fish and Wildlife Service	60	60	60
National Park Service	221	221	221
Office of Secretary			
National Business Center	32	32	32
Department of State	169	169	169
Department of Veterans Affairs	175	175	175
Environmental Protection Agency	97	97	97
Health and Human Services	20	20	20
National Aeronautics & Space Admin	6,915	6,915	6,915
National Science Foundation	3	3	3
Nuclear Regulatory Commission	363	363	363
Subtotal (Federal sources)	15,832	15,832	15,832
Total (reimbursements)	**21,266**	**21,266**	**21,266**
Total: Natural Hazards *	**149,096**	**156,225**	**167,060**

* This table does not include obligations for the Spectrum Relocation Fund, since it is a mandatory fund. MAX obligations do include the Spectrum Relocation Fund. The amounts included in MAX are: FY 2014 $651K; FY 2015 $343K; and FY 2016 $9,335K. This table does not include obligations from the unobligated balance transfer from USAID., which is included in MAX. The amount for FY 2014 is $50K.

	2014 Actual	2015 Enacted	2016 Estimate
Surveys, Investigations, and Research (SIR)			
Water Resources			
Appropriated			
Multi-Year appropriation	207,845	209,851	222,297
Total (appropriated)	**207,845**	**209,851**	**222,297**
Reimbursements			
Non-Federal (Domestic) sources			
Permittees & licensees- Fed Energy Regulatory Commission	5,822	5,822	5,822
Technology Transfer	2,656	2,656	2,656
Miscellaneous	2,933	2,933	2,933
Subtotal (non-Federal domestic sources)	11,411	11,411	11,411
Non-Federal (Foreign) sources			
National Drilling Company	210	210	210
The Environment Agency - Abu Dhabi	581	581	581
The World Bank Group	558	558	558
Miscellaneous	217	217	217
Subtotal (non-Federal Foreign sources)	1,566	1,566	1,566
State and local sources			
States-Coop (matched)	59,474	57,710	60,709
States-Coop (matched - In-Kind Services) NON ADD	2,139	2,139	2,139
States-Coop (unmatched)	100,265	102,029	99,030
Subtotal (state and local sources)	159,739	159,739	159,739
Federal sources			
Agency for International Development	45	45	45
Department of Agriculture	1,015	1,015	1,015
Department of Commerce			
Nat'l Oceanic & Atmospheric Admin	329	329	329
Department of Defense			
Corps of Engineers	32,079	32,079	32,079
Other	10,158	10,158	10,158
Department of Energy			
Bonneville Power Administration	6,562	6,562	6,562
Other	149	149	149
Department of Homeland Security	3,338	3,338	3,338
Department of Interior			
Bureau of Indian Affairs	287	287	287
Bureau of Land Management	2,427	2,427	2,427
Bureau of Reclamation	18,324	18,324	18,324
Fish and Wildlife Service	2,746	2,746	2,746
National Park Service	1,802	1,802	1,802
Office of Secretary			
National Business Center	352	352	352
Other	37	37	37
Department of Justice	13	13	13
Department of State	1,958	1,958	1,958
Environmental Protection Agency	23,844	23,844	23,844
Health and Human Services	131	131	131
National Aeronautics & Space Admin	344	344	344
National Science Foundation	82	82	82
Nuclear Regulatory Commission	61	61	61
Tennessee Valley Authority	440	440	440
Subtotal (Federal sources)	106,523	106,523	106,523
Total (reimbursements)	**279,239**	**279,239**	**279,239**
Total: Water Resources	**487,084**	**489,090**	**501,536**

	2014 Actual	2015 Enacted	2016 Estimate
Surveys, Investigations, and Research (SIR)			
Core Science Systems			
Appropriated			
Multi-Year appropriation	109,652	107,797	125,980
Total (appropriated)	**109,652**	**107,797**	**125,980**
Reimbursements			
Non-Federal (Domestic) sources			
Technology Transfer	75	75	75
Miscellaneous	1,220	1,220	1,220
Subtotal (non-Federal domestic sources)	1,295	1,295	1,295
State and local sources			
States-Coop (unmatched)	6,001	6,001	6,001
Subtotal (state and local sources)	6,001	6,001	6,001
Federal sources			
Department of Agriculture	4,689	4,689	4,689
Department of Commerce			
Nat'l Oceanic & Atmospheric Admin	227	227	227
Department of Defense	2,030	2,030	2,030
Department of Education	50	50	50
Department of Energy			
Bonneville Power Administration	70	70	70
Department of Homeland Security	2,690	2,690	2,690
Department of Interior			
Bureau of Indian Affairs	273	273	273
Bureau of Land Management	213	213	213
Bureau of Ocean Energy Management	215	215	215
Bureau of Reclamation	1,137	1,137	1,137
Fish and Wildlife Service	559	559	559
National Park Service	1,200	1,200	1,200
Department of State	101	101	101
Department of Treasury	50	50	50
Department of Veterans Affairs	25	25	25
Environmental Protection Agency	304	304	304
General Services Administration	50	50	50
Health and Human Services	86	86	86
Housing and Urban Development	50	50	50
National Science Foundation	983	983	983
Nuclear Regulatory Commission	50	50	50
Miscellaneous	25	25	25
Subtotal (Federal sources)	15,077	15,077	15,077
Total (reimbursements)	**22,373**	**22,373**	**22,373**
Total: Core Science Systems *	**132,025**	**130,170**	**148,353**

* This table does not include obligations from the unobligated balance transfer from USAID, which is included in MAX. The amount for FY 2014 is $392K.

	2014 Actual	2015 Enacted	2016 Estimate
Surveys, Investigations, and Research (SIR)			
Science Support			
Appropriated			
Multi-Year appropriation	107,743	107,894	112,468
Total (appropriated)	**107,743**	**107,894**	**112,468**
Reimbursements			
Non-Federal (Domestic) sources			
Map Receipts	1,243	1,243	1,243
Sale of photos, reproductions, and digital products	676	676	676
Technology Transfer	56	56	56
Subtotal (non-Federal domestic sources)	1,975	1,975	1,975
Federal sources			
Department of Agriculture	10	10	10
Department of Commerce			
Nat'l Oceanic & Atmospheric Admin	2,009	2,009	2,009
Department of Defense	2,877	2,877	2,877
Department of Homeland Security	16	16	16
Department of Interior			
Bureau of Indian Affairs	81	81	81
Bureau of Safety and Environmental Enforcement	109	109	109
Fish and Wildlife Service	131	131	131
National Park Service	2,037	2,037	2,037
Office of Secretary			
National Business Center	2,516	2,516	2,516
Other	577	577	577
Office of Surface Mining	5	5	5
General Services Administration	12	12	12
Sale of maps, photos, reproductions, & digital products	992	992	992
Miscellaneous	66	66	66
Subtotal (Federal sources)	11,438	11,438	11,438
Total (reimbursements)	**13,413**	**13,413**	**13,413**
Total: Science Support *	**121,156**	**121,307**	**125,881**

* This table does not include obligations for the Spectrum Relocation Fund, since it is a mandatory fund. MAX obligations do include the Spectrum Relocation Fund. The amounts included in MAX are: FY 2015 $440K; and FY 2016 $839K.

	2014 Actual	2015 Enacted	2016 Estimate
Surveys, Investigations, and Research (SIR)			
Facilities			
Appropriated			
Multi-Year appropriation	95,170	92,268	106,352
No-Year appropriation	11,903	11,965	7,280
Total (appropriated)	**107,073**	**104,233**	**113,632**
Total: Facilities	**107,073**	**104,233**	**113,632**
SIR Summary:			
Appropriated			
Multi-Year appropriation	971,063	985,856	1,103,591
No-Year appropriation	64,602	65,896	81,917
subtotal (appropriated)	1,035,665	1,051,752	1,185,508
Reimbursements			
Non-Federal Sources			
Map Receipts	1,243	1,243	1,243
Domestic	30,960	30,960	30,960
Foreign	3,936	3,936	3,936
State and local sources	167,486	167,486	167,486
Federal Sources	247,463	247,463	247,463
subtotal (reimbursements)	451,088	451,088	451,088
Total: SIR *	**1,486,753**	**1,502,840**	**1,636,596**

* This table does not include obligations for the Spectrum Relocation Fund, since it is a mandatory fund. MAX obligations do include the Spectrum Relocation Fund. The amounts included in MAX are: FY 2014 $651K; FY 2015 $783K; and FY 2016 $10,174K. This table also does not include obligations from the unobligated balance transfer from USAID, which is included in MAX. The amount for FY 2014 is $442K.

	2014 Actual	2015 Enacted	2016 Estimate
Surveys, Investigations, and Research (SIR)			
Contributed Funds:			
Permanent, indefinite appropriation:			
Ecosystems	2,167	965	812
Climate and Land Use Change	5	0	0
Energy, Minerals, and Environmental Health	61	21	1
Natural Hazards	21	10	10
Water Resources	96	45	40
Total: Contributed Funds	**2,350**	**1,041**	**863**
Operation and Maintenance of Quarters:			
Permanent, indefinite appropriation:			
Ecosystems	7	13	11
Natural Hazards	35	95	30
Total: Operation and Maintenance of Quarters	**42**	**108**	**41**
Working Capital Fund:			
National Water Quality Lab	13,503	14,452	15,476
Hydrologic Instrumentation Facility	21,738	21,315	21,503
Other	47,181	51,326	45,141
Total: Working Capital Fund	**82,422**	**87,093**	**82,120**
Allocations from other Federal Agencies: *			
Department of the Interior: Departmental Offices			
Hurricane Sandy Supplemental	22,400	0	0
Natural Resource Damage Assessment	4,282	2,300	2,300
Total: Allocations	**26,682**	**2,300**	**2,300**

* Allocations are shown in the year they are received, not when they are obligated.

United States Geological Survey

Trust Funds

CONTRIBUTED FUNDS

Special and Trust Fund Receipts

(Millions of Dollars)

Identification Code 14-8562-0-7-306		2014 Actual	2015 Enacted	2016 Estimate
01.00	Balance, start of year	0	0	0
	Receipts:			
02.20	Contributed Funds, Geological Survey	2	1	1
04.00	Total: Balances and collections	2	1	1
	Appropriations:			
05.00	Contributed Funds	-2	-1	-1
07.99	Balance, end of year	0	0	0

Program and Financing

(Millions of Dollars)

Identification Code 14-8562-0-7-306		2014 Actual	2015 Enacted	2016 Estimate
	Obligations by program activity:			
08.01	Donations and contributed funds	2	1	1
09.00	Total new obligations	2	1	1
	Budgetary resources:			
	Unobligated balance:			
10.00	Unobligated balance brought forward, Oct 1	2	2	2
	Budget authority:			
	Appropriation, mandatory:			
12.01	Appropriation (trust fund)	2	1	1
12.60	Appropriation, mandatory (total)	2	1	1
19.30	Total budgetary resources available	4	3	3
	Memorandum (non-add) entries:			
19.41	Unexpired unobligated balance, end of year	2	2	2

CONTRIBUTED FUNDS

Program and Financing cont'd

(Millions of Dollars)

Identification Code 14-8562-0-7-306		2014 Actual	2015 Enacted	2016 Estimate
	Change in obligated balance:			
30.10	Obligations incurred, unexpired accounts	2	1	1
30.20	Outlays (gross)	-2	-1	-1
	Obligated balances, end of year (net):			
	Budget authority and outlays, net:			
	Mandatory:			
40.90	Budget authority, gross	2	1	1
	Outlays, gross:			
41.00	Outlays from new mandatory authority	0	1	1
41.01	Outlays from mandatory balances	2	0	0
41.10	Outlays, gross (total)	2	1	1
41.80	Budget authority, net (total)	2	1	1
41.90	Outlays, net (total)	2	1	1

Status of Funds

(Millions of Dollars)

Identification Code 14-8562-0-7-306		2014 Actual	2015 Enacted	2016 Estimate
	Unexpended balance, start of year			
01.00	Balance, start of year	1	2	2
	Adjustments:			
01.91	Rounding adjustment	1	0	0
01.99	Total balance, start of year	2	2	2
	Cash income during the year:			
	Current law:			
	Offsetting receipts (proprietary):			
12.20	Contributed Funds: Geological Survey	2	1	1
12.99	Income under present law	2	1	1
32.99	Total cash income	2	1	1
	Cash outgo during year:			
	Current law:			
45.00	Contributed Funds	-2	-1	-1
45.99	Outgo under current law (-)	-2	-1	-1
65.99	Total cash outgo (-)	-2	-1	-1
	Unexpended balance, end of year:			
87.00	Uninvested balance (net), end of year	2	2	2
87.99	Total balance, end of year	2	2	2

CONTRIBUTED FUNDS

Object Classification

(Millions of Dollars)

Identification Code 14-8562-0-7-306		2014 Actual	2015 Enacted	2016 Estimate
	Direct obligations:			
25.3	Other goods and services from Federal Sources	2	0	0
99.5	Below reporting threshold	0	1	1
99.9	Total new obligations	2	1	1

Employment Summary

Identification Code 14-8562-0-7-306		2014 Actual	2015 Enacted	2016 Estimate
	Direct:			
1001	Civilian full-time equivalent employment	7	7	7

Employee Count by Grade

(Total Employment)

	2014 Actual	2015 Estimate	2016 Estimate
Executive Level V	0	0	0
SES	14	22	22
Subtotal	14	22	22
SL – 00	7	9	9
ST – 00	40	40	40
Subtotal	47	49	49
GS/GM – 15	519	508	522
GS/GM – 14	757	742	762
GS/GM – 13	1,210	1,186	1,219
GS – 12	1,528	1,496	1,537
GS – 11	1,250	1,225	1,257
GS – 10	13	13	13
GS – 9	920	902	926
GS – 8	234	230	237
GS – 7	629	617	634
GS – 6	202	198	203
GS – 5	345	338	347
GS – 4	209	205	211
GS – 3	124	121	124
GS – 2	51	50	52
GS – 1	13	13	13
Subtotal	8,004	7,844	8,057
Other Pay Schedule Systems	252	252	252
Total employment (actual/estimate)	8,317	8,167	8,380

Mandatory Budget and Offsetting Collection Proposals

The USGS does not have any legislative proposals in the 2016 President's budget that impact receipts or mandatory spending levels.

Section 403 Compliance

This section describes details related to any assessments to, or within the USGS to support bureauwide services and functions. Details regarding the USGS's payments to the Department of the Interior's Working Capital Fund, and payments to other Federal Agencies are included in the External Administrative Costs subsection. Additional information on internal assessments and cost allocation methodologies can be found in the Bureau Administrative Costs subsection.

	2016 Estimate ($000)
External Administrative Costs	
The Department of the Interior's Working Capital Fund	
WCF Centralized Billings	$17,857
WCF Direct Billings	$9,875
Payments to Other Federal Agencies	
Worker's Compensation Payments	-$24
Unemployment Compensation Payments	$10
GSA Rental Payments	-$2,506
Bureau Administrative Costs	
Shared Program Costs	$12,856
Internal Bureau Overhead	$39,500

External Administrative Costs

The Department of the Interior's Working Capital Fund

The Department's Working Capital Fund was established pursuant to 43 U.S.C. 1467, to provide common administrative and support services efficiently and economically at cost. The Fund is a revolving fund, whereby capital is expended to provide services for customers who pay for the services. Customers consist of the Department's bureaus and offices, as well as other Federal agencies. Through the use of centrally provided services, the Department standardized key administrative areas such as commonly used administrative systems, support services for those located in and around the Main and South Interior building complex, and centrally managed departmental operations that are beneficial to the bureaus and offices.

Centralized billing is used whenever the product or service being provided is not severable or it is inefficient to bill for the exact amount of product or service being procured. Customers are billed each year using a pre-established basis that is adjusted annually to reflect change over time. These bills are paid for by both the Administrative & Management and the Information Services subactivities within Science Support, and payment may be adjusted accordingly between these lines during the year of execution based on the enacted appropriation. The following table provides the actual centralized billing to the USGS for 2014 and estimates for 2015 and 2016.

Working Capital Fund Revenue
Centralized Billing
Geological Survey
($ in thousands)

Activity/Office	2014 Revised	2015 Pres Budget	2015 Revised	2016 Estimate
OS Shared Services				
FBMS Infrastructure Hosting & Support	0.0	1,124.9	1,113.8	1,083.1
FBMS Hosting / Applications Management	244.2	0.0	0.0	0.0
FBMS Master Data Systems & Hosting	120.8	0.0	0.0	0.0
FBMS Redirect - IDEAS	356.4	0.0	0.0	
FBMS Redirect - FFS	1,354.6	0.0	0.0	0.0
FBMS Master Data Management	0.0	172.2	169.7	0.0
FBMS Business Integration Office	2,076.0	1,297.1	1,283.5	1,083.1
Aviation Management	512.8	430.3	430.3	432.5
Office of Aviation Services	512.8	430.3	430.3	432.5
Mail and Messenger Services	5.8	0.9	0.9	0.9
Safety, Environmental, and Health Services	3.1	0.5	0.5	0.5
Shipping/Receiving & Moving Services	1.8	0.3	0.3	0.3
Personal Property Accountability Services (formally Property)	2.6	0.4	0.4	0.4
Interior Complex Management & Svcs	2.7	0.4	0.4	0.3
Departmental Library	8.4	8.5	8.5	7.4
Mail Policy	36.1	37.2	37.2	30.7
Conference and Special Events Services	4.4	0.7	0.7	0.7
Space Management Services	1.5	0.2	0.2	0.2
Office of Facilities & Administrative Services	66.3	49.2	49.2	41.5
Subtotal OS Shared Services	2,655.2	1,776.6	1,763.0	1,557.1

Working Capital Fund Revenue
Centralized Billing
Geological Survey
($ in thousands)

Activity/Office	2014 Revised	2015 Pres Budget	2015 Revised	2016 Estimate
OS Activities				
Document Management Unit	17.9	0.0	0.0	
FOIA Tracking & Reporting System	31.2	42.8	45.7	46.8
Office of the Executive Secretariat	49.1	42.8	45.7	46.8
Alaska Affairs Office	10.8	10.8	10.8	11.0
Alaska Resources Library and Information Services	167.9	167.9	153.4	153.4
Secretary's Immediate Office	178.7	178.7	164.2	164.4
Departmental News and Information	106.4	108.4	108.4	140.7
Departmental Museum	125.8	128.8	117.0	133.8
Secretary's Immediate Office	125.8	128.8	117.0	133.8
Asbestos-Related Cleanup Cost Liabilities	0.2	0.0	0.0	
FedCenter	1.9	1.9	1.9	1.9
Compliance Support ESF-11/ESF-11 Website	2.3	2.3	2.3	2.3
Office of Environmental Policy and Compliance	4.3	4.3	4.3	4.2
Invasive Species Council	210.7	211.4	214.4	216.4
Invasive Species Coordinator	38.6	38.8	38.8	39.2
Office of Policy Analysis	249.2	250.2	253.2	255.6
CPIC	31.0	28.5	28.5	28.5
Office of Budget	31.0	28.5	28.5	28.5
Financial Statement, Internal Controls & Performance Report	83.7	59.5	59.5	76.3
Travel Management Center	31.0	31.5	31.5	38.9
e-Travel	267.8	181.7	181.7	211.3
Office of Financial Management	382.4	272.7	272.7	326.5
Interior Collections Management System	2.1	2.1	2.1	2.1
Space Management Initiative	41.6	42.5	42.5	40.9
Renewable Energy Certificates	3.0	2.9	2.9	33.0
Facility Maintenance Management System	4.6	4.6	4.6	4.6
Interior Asset Disposal System O&M	0.0	5.1	5.1	5.1
Office of Property and Acquisition Management	51.3	57.0	57.0	85.7
Planning and Performance Management	137.9	140.7	140.7	136.4
Office of Planning and Performance Management	137.9	140.7	140.7	136.4
Department-wide Worker's Compensation Program	31.9	32.0	28.7	22.5
OPM Federal Employment Services	46.8	46.4	44.6	42.6
Accessibility and Special Hiring Programs (Formerly ATC)	72.4	73.8	73.8	70.4
Human Resources Accountability Team	74.2	78.3	78.3	75.4

Working Capital Fund Revenue
Centralized Billing
Geological Survey
($ in thousands)

Activity/Office	2014 Revised	2015 Pres Budget	2015 Revised	2016 Estimate
OS Activities				
Employee and Labor Relations Tracking System	3.9	3.9	3.9	3.8
Consolidated Employee Assistance Program	0.0	92.3	92.3	83.8
Office of Human Resources	229.2	326.8	321.7	298.4
EEO Complaints Tracking System	1.7	4.5	4.5	1.4
Special Emphasis Program	4.7	4.8	4.8	4.6
Office of Civil Rights	6.4	9.3	9.3	6.0
Occupational Safety and Health	177.9	181.3	181.3	174.1
Safety Management Information System	142.8	145.4	145.4	139.4
Office of Occupational Health and Safety	320.7	326.7	326.7	313.6
Leadership Development Programs	109.5	111.9	111.9	109.1
Dept-Wide Training Programs (including Online Learning)	308.3	297.9	297.9	296.5
Learning & Performance Center Management	51.7	78.3	78.3	78.5
DOIU Management	77.4	78.9	78.9	75.8
DOI University	546.9	567.0	567.0	560.0
Security (Classified Information Facility)	55.1	66.5	57.2	58.3
Law Enforcement Coordination and Training	100.7	99.6	76.7	78.3
Security (MIB/SIB Complex)	30.0	23.8	22.2	3.6
Victim Witness Coordinator	19.8	20.7	21.7	22.2
Office of Law Enforcement and Security	205.6	210.6	177.8	162.3
Interior Operations Center	249.4	261.5	261.5	252.4
Emergency Preparedness (COOP)	125.5	127.6	112.2	107.7
Emergency Response	123.6	126.1	141.5	136.5
MIB Emergency Health and Safety	0.5	0.1	0.1	0.1
Federal Executive Board	30.9	31.5	31.5	31.5
Office of Emergency Management	529.9	546.8	546.8	528.2
Alternative Dispute Resolution (ADR) Training	5.9	6.0	6.0	5.7
Collaborative Action and Dispute Resolution	5.9	6.0	6.0	5.7
Conservation and Educational Partnerships	35.5	36.2	36.2	34.6
Office of Human Resources	35.5	36.2	36.2	34.6
Cooperative Ecosystem Study Units	51.4	51.4	51.4	50.9
CFO Financial Statement Audit	545.9	728.4	728.4	610.0
Glen Canyon Adaptive Management	130.4	130.4	130.4	130.7
Department-wide Activities	727.7	910.2	910.2	791.7
Ethics	61.9	62.9	62.9	60.2
FOIA Appeals	26.0	26.0	26.0	26.0
Office of the Solicitor	87.8	88.9	88.8	86.3
Subtotal OS Activities	3,984.2	4,191.6	4,171.0	4,111.2

Working Capital Fund Revenue
Centralized Billing
Geological Survey
($ in thousands)

Activity/Office	2014 Revised	2015 Pres Budget	2015 Revised	2016 Estimate
IT Shared Services				
IT Transformation Planning (ITT)	477.5	832.0	832.0	832.0
Office of the Chief Information Officer	477.5	832.0	832.0	832.0
Enterprise Directory Services (formerly Active Directory)	362.7	360.8	360.8	653.5
IT Asset Management	107.0	154.5	154.5	173.5
IOS Collaboration	110.0	100.7	100.7	136.4
Unified Messaging	116.0	113.3	113.3	162.0
ITD Desktop Services	17.2	0.0	0.0	
Office of IT Service Delivery - End User Services	713.0	729.2	729.2	1,125.5
Privacy and Civil Liberties	93.7	101.1	101.1	109.3
Identity Credential Access Mgmt (ICAM)	144.3	132.0	132.0	144.6
Threat Management	364.1	522.1	522.1	956.0
Information Systems Security Operations (ISSO) (Formerly ITD ISSO)	373.8	373.8	373.8	25.0
ITD PPCD Privacy Records	8.1	8.1	8.1	
Office of Information Assurance (OIA) (formerly Information	76.6	87.4	87.4	78.6
Assessment & Authorization Services	26.1	29.8	29.8	29.3
IT Security	35.8	38.7	38.7	34.2
Enterprise Continuous Diagnostics and Monitoring	0.0	124.2	124.2	124.1
Enterprise Security Information and Event Mgmt Solution (SIEM)	0.0	268.7	268.7	268.4
Office of Information Assurance	1,122.5	1,685.9	1,685.9	1,769.5
Hosting Services (formerly Hosting/Cloud Services)	37.5	63.9	63.9	134.7
Office of Hosting Services	37.5	63.9	63.9	134.7
Electronic Records Management	217.6	311.2	217.6	311.2
Solutions, Design and Innovation (SDI)	48.6	49.4	49.4	127.6
Geospatial Services	0.0	0.0	0.0	27.4
Office of Information and Technology Management	266.2	360.7	360.7	627.5
Enterprise Services Network	2,579.0	1,054.2	1,054.2	1,160.5
Frequency Management Support	79.5	86.2	77.9	69.8
NTIA Spectrum Management	146.8	135.7	135.7	113.1
Radio Program Management Office	84.5	81.4	81.4	74.1
Federal Relay Service	6.0	7.1	7.1	28.4
ITD MIB Data Networking	1.6	1.6	1.6	0.3
ITD Telecommunication Services	3.7	3.7	3.7	0.8
ITD Integrated Digital Voice Communications System	2.7	2.7	2.7	0.6
Enterprise Services Network - Central Bill Pass Thrus	0.0	1,567.2	1,567.2	2,257.7
Office of IT Service Delivery - Telecommunications Services	2,903.8	2,939.8	2,931.4	3,705.3
FBMS Help Desk – Customer Support Center	451.1	0.0	0.0	
Enterprise Service Desk	0.0		0.0	95.5
Office of IT Service Delivery - Customer Support Services	451.1	0.0	0.0	95.5

Working Capital Fund Revenue
Centralized Billing
Geological Survey
($ in thousands)

Activity/Office	2014 Revised	2015 Pres Budget	2015 Revised	2016 Estimate
IT Shared Services				
Enterprise Resource Management	201.3	184.2	184.2	
Office of Business Operations	201.3	184.2	184.2	
Architecture & IT Portfolio Performance Management	395.6	451.5	451.5	492.0
Independent Verification and Validation - Risk Mgmt (formerly IT	240.7	259.6	259.6	285.7
IT Budget Formulation & Portfolio Development	295.5	337.2	337.2	305.0
e-Government Initiatives (WCF Contributions Only)	364.4	457.8	457.8	376.4
Volunteer.gov	15.1	15.1	15.1	15.1
OCIO e-Government Initiatives	379.5	472.9	472.9	391.5
Subtotal IT Shared Services	7,484.2	8,316.8	8,308.5	9,764.2
Interior Business Center				
FPPS/Employee Express - O&M	2,185.9	2,167.9	2,021.6	2,023.9
Drug Testing	8.5	8.5	8.5	28.5
IBC Human Resources Directorate	2,194.4	2,176.4	2,030.0	2,052.4
Financial Systems	553.6	0.0	0.0	0.0
IDEAS	26.8	0.0	0.0	0.0
Quarters Program	1.3	1.3	1.3	1.0
FBMS Master Data Management	170.3	0.0	0.0	
Consolidated Financial Statement System	138.7	0.0	0.0	0.0
IBC Financial Management Directorate	890.7	1.3	1.3	1.0
Boise Acquisition Office	136.9	348.2	348.2	370.7
IBC Acquisitions Services Directorate	136.9	348.2	348.2	370.7
Subtotal Interior Business Center	3,222.0	2,525.9	2,379.5	2,424.1
TOTAL	17,345.6	16,810.9	16,622.0	17,856.7

Direct billing is used whenever the product or service provided is again severable, but is sold through a time and materials reimbursable support agreement or similar contractual arrangement. The following tables provide the actual direct and reimbursable collections from the USGS for 2013, and estimated billings and collections for 2014 and 2015.

Working Capital Fund Revenue
Direct Billing
Geological Survey
($ in thousands)

Activity/Office	2014 Actual	2015 Pres Budget	2015 Estimate	2016 Estimate
OS Shared Services				
Creative Communications	5.9	6.0	6.0	6.7
Ofc of Facilities & Admin Services	5.9	6.0	6.0	6.7
FBMS Change Orders	180.0	0.0	0.0	0.0
FBMS Business Integration Office	180.0	0.0	0.0	0.0
Subtotal OS Shared Services	185.9	6.0	6.0	6.7
OS Activities				
Imagery for the Nation (IFTN)	950.0	950.1	950.1	950.0
Policy, Management and Budget	950.0	950.1	950.1	950.0
Office of Environmental Policy and Compliance				
Ocean Coastal Great Lakes Activities	40.0		40.0	40.0
Office of Policy Analysis	40.0		40.0	40.0
Office of Budget				
Single Audit Clearinghouse	0.2	1.5	0.2	0.2
Office of Financial Management	0.2	1.5	0.2	0.2
e-OPF	157.9	157.9	157.9	133.8
Office of Human Resources	157.9	157.9	157.9	133.8
EAP Consolidation	109.6	0.0	0.0	0.0
Worker's Comp Nurse Case Management	15.9	15.8	15.8	15.8
Office of Human Resources	125.6	15.8	15.8	15.8
Equal Employment Opportunity (EEO) Investigations	3.0	3.0	3.0	3.9
Equal Employment Opportunity (EEO) Training	0.0	0.0	1.5	1.5
Office of Civil Rights	3.0	3.0	4.5	5.4
Albuquerque Learning & Performance Center	8.8	8.6	0.0	0.0
Denver Learning & Performance Center	20.2	19.8	0.0	0.0
Online Learning	57.5	57.5	58.7	61.4
Washington Leadership & Performance Center	33.6	32.9	0.0	0.0
Consolidated Direct Billed Leadership & Performance Center	0.0		61.3	61.3
DOI University	120.1	118.9	120.0	122.7
Federal Flexible Savings Account (FSA) Program	159.9	159.9	52.6	52.6
Department-wide Programs	159.9	159.9	52.6	52.6
Subtotal OS Activities	1,556.7	1,407.0	1,341.21	1,320.5

Working Capital Fund Revenue
Direct Billing
Geological Survey
($ in thousands)

Activity/Office	2014 Actual	2015 Pres Budget	2015 Estimate	2016 Estimate
IT Shared Services				
Unified Messaging	1,003.8	1,630.3	1,109.7	1,256.7
End User Services	1,003.8	1,630.8	1,109.7	1,256.7
Anti-Virus Software Licenses	279.9	308.0	308.0	308.0
Identity, Credential Access Management (ICAM)	926.6	882.8	984.2	1,122.3
Data at Rest Initiative	15.2	16.9	15.2	15.0
ITD ISSO Information Assurance Operations	28.4		28.4	31.4
Enterprise Continuous Diagnostics and Monitoring	1.6			
Information Assurance Operations Services	1,251.7	1,207.6	1,335.8	1,476.7
Hosting Services		90.5	97.6	114.4
ITD ISSO Hosting Services	193.5	331.7	206.2	377.3
Hosting Services	193.5	422.2	303.8	491.7
Electronic Records Management	533.0		533.5	600.3
Information Management and Assurance	533.0		533.5	600.3
Enterprise Services Network	2,743.9	4,141.7	2,708.2	2,706.8
ISSO ITD Telecommunications	10.9	2.7		
ISSO ITD Network Support Services		2.6	11.4	12.9
Telecommunications Services	2,754.8	4,147.1	2,719.7	2,719.7
ITD Customer Support Services Division	0.3		0.3	0.3
Customer Support Services	0.3		0.3	0.3
ESRI Enterprise Licenses	36.6	1,119.4	1,120.8	1,141.7
Geospatial Services	36.6	1,119.4	1,120.8	1,141.7
Architecture & IT Portfolio Performance Management	793.2	0.0		
DOI Planning and Portfolio Management	793.2	0.0		
Subtotal IT Shared Services	6,566.9	8,526.6	7,123.5	7,687.1
Interior Business Center				
Payroll & HR Systems	916.7	933.0	843.8	855.0
IBC Human Resources Directorate	916.7	933.0	843.8	855.0
Indirect Cost Negotiations – DOI Support			9.7	6.1
IBC Financial Management Directorate			9.7	6.1
Acquisition Services	0.4			
IBC Acquisition Services Directorate	0.4			
Subtotal Interior Business Center	917.2	933.0	853.5	861.1
TOTAL	9,226.8	10,872.6	9,324.1	9,875.5

Payments to Other Federal Agencies

	2014 Actual	2015 Change	2016 Change
Worker's Compensation Payments	2,704	-343	-24
The adjustment is for the change in costs of compensating injured employees and dependents of employees who suffer accidental deaths while on duty. Costs for the BY will reimburse the Department of Labor, Federal Employees Compensation Fund, pursuant to 5 U.S.C. 8147(b) as amended by Public Law 94-273.			
Unemployment Compensation Payments	632	-38	10
The adjustment is for projected changes in the costs of unemployment compensation claims to be paid to the Department of Labor, Federal Employees Compensation Account, in the Unemployment Trust Fund, pursuant to Public Law 96-499.			
GSA Rental Payments	82,851	853	-2,506
The adjustment is for changes in the costs payable to General Services Administration (GSA) and others resulting from changes in rates for office and non-office space estimated by GSA, as well as the rental costs of other currently occupied space. These costs include building security, the case of GSA space, these are paid to DHS. Costs of mandatory office relocations, i.e., relocations in cases where due to external events there is no alternative but to vacate the currently occupied space, are also included.			

* 2015 Change in Rental Payment was calculated using initial 2014 Rental amounts in the June 2012 Exhibit 54. This number is continually updated; above figures may not reflect the most up-to-date estimates, and may be understated.

Bureau Administrative Costs

Shared Program Costs

The USGS maintains less than one percent of its appropriation for other bureau-wide support and science-related activities. These funds are used for initiatives which may be unfunded mandates, are crosscutting in nature, or respond to new and emerging scientific issues.

The funding for the initiatives in the Shared Program Costs are assessed at the budget activity level, based upon one of two methodologies: proportionately, based on total appropriated funds for the mission area; or proportionately, based on total funds for the mission area, including reimbursable funding sources, and are distributed to the initiatives efficiently. The methodology used is tied to the nature of the initiative. For instance, an initiative that is crosscutting to all the mission areas, but is purely an Interior priority (one in which an external partner is not a stakeholder, nor receives direct benefit of the service) would receive its funding based upon a calculation on appropriated funds only. Conversely, an initiative where all customers of the USGS either directly or indirectly receive benefit, such as the aforementioned information technology compliance and security upgrades, would be calculated to each of the mission areas based upon all funding sources, both appropriated and reimbursable. The initiatives on the Shared Program Cost Chart are vetted each year with the Executive Leadership Team of the USGS, and are decided upon in a voting process to ensure bureauwide concurrence.

The following initiatives are currently planned for the USGS's 2016 Shared Program Costs:

2016 Shared Program Cost Chart

Mission Area	Ecoysystems	Climate & Land Use Change	Energy, Minerals, and Environmental Health	Natural Hazards	Water Resources	Core Science Systems	Total
Delta Science **	123,928	107,312	72,821	106,690	166,733	84,625	662,109
Grand Canyon Monitoring**	188,563	163,269	110,792	162,321	253,674	128,751	1,007,370
Regional Science**	487,585	422,179	286,485	419,729	655,947	332,924	2,604,849
John Wesley Powell Center**	88,063	76,250	51,742	75,808	118,471	60,130	470,464
International Program**	302,080	261,558	177,490	260,040	406,387	206,261	1,613,816
IT Transformation*	757,882	536,213	344,362	512,593	1,607,075	424,620	4,182,745
Web Re-engineering*	419,460	296,775	190,592	283,702	889,459	235,012	2,315,000
Total Program Costs	**2,367,561**	**1,863,556**	**1,234,284**	**1,820,883**	**4,097,746**	**1,472,323**	**12,856,353**

*Proportionally spread by total funds.
**Proportionally spread by appropriated funds.

Delta Science – The California Bay-Delta is recognized as one of the world's threatened treasures of biodiversity, which supports unique native species and their critical tidal habitats. The USGS participates in the Delta Science Federal-State partnership which coordinates the efforts of 25 State and Federal agencies to improve the quality and reliability of California's water supplies while restoring the Bay-Delta ecosystem. USGS science contributes to restoration challenges such as water supply reliability, water quality, sustainability of native species, and flood risk.

Grand Canyon Monitoring – The USGS's Grand Canyon Monitoring and Research Center (GCMRC) is the science provider for the Glen Canyon Dam Adaptive Management Program. In this role, the research center provides the public and decisionmakers with relevant scientific information about the status and trends of natural, cultural, and recreational resources found in those portions of Grand Canyon National Park and Glen Canyon National Recreation Area affected by Glen Canyon Dam operations.

Regional Science – The implementation of the USGS Science Strategy calls for the integration of the full breadth and depth of USGS capabilities; building on existing strengths and partnerships. To that end, many of the USGS's historical "single-discipline" science centers are now reflections of this science strategy, and perform research and conduct science across many USGS mission areas, and need to respond quickly to new and emerging science issues. This funding brings scientists together to work across teams and across regions, to respond to the Nation's highest and changing priorities, respond to global trends, and conduct the best possible science.

John Wesley Powell Center – The John Wesley Powell Center for Analysis and Synthesis serves as a catalyst for innovative thinking in Earth system science research. Initiated as one means of implementing the USGS Science Strategy, the Powell Center supports scientist-driven interdisciplinary analysis and synthesis of complex natural science problems. USGS scientists are encouraged to propose working groups reflecting a mix of USGS scientists and their colleagues from government and academia focused on major earth science issues. The Powell Center work generates cutting-edge, high-visibility publications.

International Programs – The Office of International Programs is dedicated to high quality, timely, scientific study that is international in scope and that focuses on the USGS Science Strategy's themes. As one of the world's premier science agencies, the USGS has long recognized the mutual benefits resulting

from interaction with scientific partners abroad and extending research and investigations to other countries. By providing reliable scientific information about the Earth and its resources from an international perspective, the USGS Office of International Programs supports US foreign policy and national security; provides a basis for science diplomacy, and improves the scientific basis for managing ecosystems and natural resources.

DOI IT Transformation – This funding will be used to support Interior's efforts in IT Transformation. These funds will support the Department's activities related to data center consolidation, single-source messaging, and cloud-based electronic forms, records, documents and content management solutions.

Web Reengineering – This funding will streamline and organize USGS's web presence to create a more effective and manageable Web presence and to provide Web-enabled technology, real-time access, social and collaborative cloud-based tools, and extensive use of mobile and tablet devices.

Internal Bureau Overhead Cost Allocation Methodology

The USGS manages overhead costs at two levels—the bureau and science center. Bureau level costs include headquarters and area executive, managerial, supervisory, administrative, and financial functions and bureauwide systems. At the bureau level, funding appropriated to the Science Support budget activity pays the bureauwide overhead costs in the same proportion as appropriated funding is to total funding. For this reason, bureauwide overhead costs collected on reimbursable support agreements are deposited within Science Support program areas, as well.

The USGS assesses a bureau overhead rate, estimated to remain at 12 percent, on reimbursable work from non-Interior customers to recoup their share of bureau-level costs. In some cases, the USGS assesses a special or reduced rate when it can be demonstrated that indirect costs are substantially and consistently less than the norm and the amount collected covers the full costs, such as with pass-through funding where the Survey does not perform any of the actual work. The following table shows the funding available to the Science Support program, including the anticipated overhead collections to pay for bureauwide costs.

(Dollars in Thousands)

Source of Funding	2016 Budget Request	2016 Estimated Bureau Overhead Distribution	2016 Estimated Total
Science Support			
Administration and Management	90,599	30,810	121,409
Information Services	22,229	8,690	30,919
Total Funding	**112,828**	**39,500**	**152,328**

At the science center level, because there generally is not an appropriated funding source to pay the local overhead (common services) costs, both the appropriated and reimbursable funding are assessed a percentage to cover their share of science center-level costs. Science center common services costs include center costs that are not directly attributable to a specific activity or project, such as managerial,

supervisory, administrative, and financial functions and related systems, as well as costs incidental to providing services and products, such as postage, training, miscellaneous supplies and materials. The cost during 2014, for the local overhead, totaled $190 million from both appropriated and reimbursable funds.

In recognition of the USGS role as the science bureau for the Department of the Interior, the USGS is continuing to give Interior bureaus and offices a "preferred" customer rate on overhead charges for a significant portion of reimbursable work, to the extent that matching funds are available within the USGS budget. The maximum rate that cost centers may charge other Interior bureaus for common services and bureau costs combined remains 15 percent net. In 2014, of the 15 percent, 7.5 percent is applied to bureau costs, and the remaining 7.5 percent is applied to common services costs. Cost centers must fund the common services costs not recovered (e.g., the difference between the cost center's standard common services costs and the 7.5 percent) from USGS appropriated funds. In this way, the USGS is partnering on the science needs of Interior from both the bureau and cost centers.
The Chief Financial Officer establishes the USGS bureau special rate for each fiscal year. The special rate for 2014 is estimated to remain at three percent. Cost centers do not charge more than the bureau special rate for facilities-related costs or their standard common services rate when funding is approved for a bureau-level special rate. Special rates are applied under the following circumstances:

- When the USGS receives funds from a non-USGS organization and awards a grant to a third-party entity.
- When the USGS receives funds from one or more non-USGS organizations to support, under USGS leadership, a strategic science objective that includes the USGS passing through funds to one or more third-party entities.
- When the USGS receives funds from a non-USGS organization for the purpose of the customer acquiring services through the Cartographic Services or the Remotely Sensed Data Contracts. The special rate helps encourage other Federal agencies to use these contracts for cartographic services and remotely sensed data, rather than establishing and managing their own contracts, and ensures greater data consistency through the use of common service providers.
- When the USGS receives funds from a non-USGS organization for the purpose of passing through the customer's funds to State and local governments for the direct purchase of geospatial data.
- Ecosystem’s Cooperative Research Units (CRUs) are supported by a three-way partnership including the USGS, a State, and a university. The academic institutions where CRUs are co-located provide significant administrative support. In recognition of the direct services support received from the non-USGS partners, CRUs only recover one-half of the bureau rate (six percent) normally recovered from reimbursable customers or partners.

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