



— BUREAU OF —
RECLAMATION

FY 2022 Science Strategy Annual Implementation Plan

**Science and Technology Program
Research and Development Office**



Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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1. Introduction

To support progress in addressing the research areas and categories identified in the *Science and Technology Program–Strategic Science Priorities–FY 2018-FY 2021*, this document identifies the specific research needs for each category the Science and Technology Program (S&T) is interested in addressing through research projects during the FY2022 call for proposals.

1.1. Research Roadmaps

Research Roadmaps are an intensive effort to elicit and illuminate the needs within a research category. Roadmapping may be done within a research area, research category, or research needs that requires a deeper dive to discover specifics. These efforts are sponsored by S&T and involve bureau-wide input. Roadmaps typically require six months to one year to complete.

1.2. Regional Director Needs

Each year, prior to the Call for Proposals, S&T solicits Regional Directors for a list of their highest priority research needs for a given year. These needs evolve year-to-year and are published in the annual Call for Proposals. S&T works to be responsive and address these needs by developing a combination of solicited and brokered proposals. For a list of the FY 2022 S&T Program Regional Director Needs, [please visit this document](#).

1.3. Partnerships

S&T maintains partnerships with a variety of federal, state, and local government agencies, as well as non-profits, universities, and private entities. During coordination opportunities with these partners, collaborative research opportunities are identified. This allows S&T to share the funding burden of the project and expand the knowledge base contributing to the project.

1.4. Prize Competitions

Since 2015, several prize competitions launched and closed with over 750 solutions submitted and 150 winning ideas. Many of the solutions are in the form of idea descriptions or theoretical solutions, that essentially serve as fresh starting points for new research and development activities. Other solutions are more mature and are ready for technology demonstration to further reduction-to- practice.

A summary matrix of the completed prizes and solutions can be viewed here ([access to this document is for DOI employees only](#)). Additional prize information can be accessed at <https://www.usbr.gov/research/challenges/index.html> and by coordinating with the Prize Contact listed in the summary matrix linked above. In the following sections, research needs are identified that are associated with both completed prize competitions (designated with a ++ symbol) and competitions that are ongoing. Researchers with interest in advancing prize solutions from completed competitions are strongly encouraged to coordinate with the Prize Contact listed in the summary matrix linked above and associated Research Coordinator identified below.

2. Fiscal Year 2018-2022 Science Priorities

The table and narrative descriptions below represent S&T’s priority research areas and categories for fiscal year (FY) 2018-2022.

Research Area	Research Category
Water Infrastructure (WI)	<ul style="list-style-type: none"> ▪ Dams ▪ Canals ▪ Pipelines ▪ Miscellaneous Water Infrastructure
Power and Energy (PE)	<ul style="list-style-type: none"> ▪ Hydro Powerplants ▪ Energy Efficiency ▪ Pumping Plants ▪ Non-Hydropower Renewables
Environmental Issues for Water Delivery and Management (EN)	<ul style="list-style-type: none"> ▪ Water Delivery Reliability ▪ Invasive Species ▪ Water Quality* ▪ Sediment Management ▪ River Habitat Restoration
Water Operations and Planning	<ul style="list-style-type: none"> ▪ Water Supply and Streamflow Forecasting ▪ Water Operations Models and Decision Support Systems ▪ Open Data* ▪ Climate Change and Variability
Developing Water Supplies	<ul style="list-style-type: none"> ▪ Advanced Water Treatment ▪ Groundwater Supplies ▪ Agricultural and Municipal Water Supplies ▪ System Water Losses

*Cross-cutting research areas

3. FY 2022 Research Needs

This section outlines short lists of research needs by research area and category.

3.1. Water Infrastructure (WI)

Improve the reliability of Reclamation water storage, water delivery, and facilities by producing or advancing effective solutions, tools, and practices that Reclamation facility managers can use to cost effectively maintain, modernize, and extend the life of Reclamation's aging infrastructure. These should be related to Reclamation's operations and maintenance responsibilities.

3.1.1. Dams

Description

Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, service life, and safety.

Coordination Contacts

Erin Foraker and Bobbi Jo Merten

Source of Research Needs

[Research Priorities to Enhance Dam Infrastructure Sustainability](#)

Geotechnical Research Roadmap:

https://www.usbr.gov/main/qoi/docs/Geotechnical_Research_Roadmap_FINAL.pdf

Needs Statements

1. Investigate economical, safe, and effective methods to remove medium to large debris accumulating on storage and diversion dam intake structures, in support of budgetary constraints and the increasing wildfires exacerbating the issue in the western states.
2. Investigate methods to detect erosion of material under spillway slabs and into spillway underdrains and materials and methods to repair voids under spillway slabs (cross cutting with Canals), specifically in low probability, high consequence scenarios like Oroville Dam.
3. Develop modeling tools to predict the rate of deterioration and strength loss in concrete, including alkali aggregate reaction.
4. Develop a consistent guideline for seismic analyses of concrete dams that integrates the seismic input loads with the FE analysis techniques and serves as a reference for analysts and dam owners. In a guideline, a methodical process would be developed together with the procedures for calibrating the FE models at different complexity levels and verifying and interpreting the analysis results considering various input parameters.

5. Research innovative design criteria, standards, and materials for new construction or major modifications. Perform historical analyses and “lessons learned” investigations as appropriate.
6. Improve internal erosion risk assessments, including improved methods to model field conditions in a laboratory setting and improved integration of field observations and laboratory testing (cross-cutting with Canals). ++
7. Advance geotechnical laboratory and field testing practices, with emphasis on characterization of cyclic and post-cyclic soil behavior and soil modulus, erodibility of earth materials as related to structure reliability and sediment removal, characterization of engineering properties of gravelly and cobbly soil, and internal erosion (cross-cutting with Canals).
8. Enhance science and engineering to close the gaps between laboratory testing and numerical modeling and between numerical modeling and field performance (cross-cutting with Canals).

3.1.2. Canals

Description

Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, efficiency, service life, and safety.

Coordination Contacts

Erin Foraker and Bobbi Jo Merten

Source of Research Needs

[Research Priorities to Enhance Canals Infrastructure Sustainability](#)

Needs Statements

1. Enhanced science and engineering understanding of observations to determine quantifiable thresholds for action, particularly as they relate to risk assessment (cross cutting with Pipelines). Examples include encroachments within or outside right-of-ways, seepage progression, consequences due to failure, or changes due to operations.
2. Evaluate methods and materials to detect and fill or repair voids under canal lining (cross cutting with Dams).
3. Develop underwater canal lining repair materials and methods for cracked, buckled, or bulged linings (underwater crack sealants, grouts, etc.) or underwater canal panel placement material or method.
4. Develop improved, less expensive canal lining, cover, and repair materials and methods.
5. Identify improved inspection methods to reduce siphon pipe failure rates. Less expensive repair methods to repair pipe in lieu of replacement and associated costs (cross cutting with Pipelines).

6. Investigate methods, technologies, or approaches to reduce the incidence of canal drownings by improving physical aspects, sensing, or response techniques.
7. Identify economical methods and techniques to improve impacts due to subsidence.

3.1.3. Pipelines

Description

Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, efficiency, service life, and safety.

Coordination Contacts

Erin Foraker and Bobbi Jo Merten

Source of Research Needs

[Research Priorities to Enhance Pipeline Infrastructure Sustainability](#)

Needs Statements

1. Improve tunnel condition assessment techniques and repair methods. Determine cost-effectiveness and constructability of alternatives.
2. Investigate non-metallic pipes for large diameter and high-pressure use.
3. Research ROV instrumentation and faster data analysis for evaluating pipe condition assessment, for example coatings and linings, and pipe material, obstructions, and detecting leaks.
4. Demonstrate low- or no-power tools or sensors for detecting or monitoring metallic corrosion when embedded in concrete pipes including prestressed concrete cylinder pipes (cross cutting with Canals).
5. Enhance science and engineering understanding of observations to determine quantifiable thresholds for action, particularly as they relate to risk assessment (cross cutting with Canals). Examples include pipe leaks, consequences due to failure, or changes due to operations.

3.1.4. Miscellaneous Infrastructure

Description

Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, efficiency, service life, and safety.

Coordination Contacts

Erin Foraker and Bobbi Jo Merten

Source of Research Needs

There is no research roadmap currently available for this category.

Needs Statements

1. Data standards - Evaluate standardized data collection approaches for inspections to facilitate improved data processing or predictive or condition-based maintenance. Develop approaches to better document as-built conditions at time zero, i.e., baseline conditions.
2. Data processing and access - Develop solutions, tools, and practices to improve analysis of large datasets, such as from photogrammetry or other detection methods, including 3D data visualization. Improve data accessibility and streamline design processes through incorporation of real-time data.
3. Predictive maintenance - Research machine learning, artificial intelligence, algorithms, or other solutions to develop a predictive or condition-based maintenance approach for assets (cross cutting with Power and Energy).
4. Safety - Research projects that focus on improving the safety of the public and Reclamation personnel and operations, such as robotics, improved hearing protection, improved hazardous energy detection, etc.
5. Security-Develop solutions, tools, and practices to further Reclamation's understanding of current or developing threat tactics and security risks related to emerging technologies. The research should result in data and conclusions that can be integrated into Reclamation's security program to provide Reclamation with an enhanced capability to evaluate and manage risk at its critical infrastructure. For additional details regarding security related research needs, [please reference this document](#).

3.2. Power and Energy (PE)

Develop and advance operations and maintenance solutions, tools, and practices that improve the reliability, efficiency, and safety of Reclamation's hydropower and pumping facilities in order to reduce costs, increase energy supplies, and add value, ensuring Reclamation's hydropower remains a long-term, cost-competitive energy resource within quickly-changing energy markets.

3.2.1. Hydro Powerplants

Description

Examine, develop, and deploy tools, methods, practices and strategies to improve safety, operations and maintenance, reliability, efficiency, outage time, and output.

Coordination Contact

Erin Foraker

Source of Research Needs

For additional details regarding hydropower protection system related research needs, please reference the [Research Priorities for Mechanical Components of Hydropower Units](#) and the [FY 2021 Call PE General Needs document](#).

Needs Statements

1. Hydropower generation and associated equipment
 - a. Improve safety and occupational health, including but not limited to, with rotating machinery and personal protective grounding methods.
 - b. Increase hydropower equipment reliability and performance, including but not limited to, improved generator insulation systems and maintenance strategies.
 - c. Evaluate, investigate, and develop less invasive and labor intensive maintenance tasks or automated techniques related to hydropower protection and control systems, excitation and governor systems, and other hydropower equipment.
 - d. Examine and develop new operations and maintenance philosophies and instrumentation that utilize new sensor technologies, data sampling strategies, system integration, digitization and data science tools.
 - e. Develop methods to authenticate and improve hydropower value to support sustainable, cost-competitive hydropower resource within quickly-changing energy markets, including but not limited to, new energy storage technologies and evaluation of ancillary services.
2. Hydropower Operation, Control, and Monitoring
 - a. Increase reliability, efficiency, and performance, including but not limited to, generator excitation and control.
 - b. Investigate, develop, and implement improved hydropower condition monitoring systems.
 - c. Develop and implement new data science technique to reduce cost, improve reliability, and increase efficiencies (cross cutting with Water Infrastructure Section 3.1.4.).
3. Mechanical equipment–penstocks
 - a. Improve durability and extend service life for coatings materials in high-velocity environments.
 - b. Improve coating materials for application in low temperature and humid conditions.
 - c. Develop or advance inspection and coating application and repair methods for large pipes and penstocks with difficult-to-access or dangerous geometries (e.g., complex geometry, steep slopes, drops, etc.). Inspection methods should improve data quality and reduce inspection time.

4. Mechanical equipment–gates and valves
 - a. Improve durability and extend service life for coatings materials in locations prone to high velocity, erosion, and cavitation.
 - b. Develop or improve inspection methods for submerged equipment (e.g., bulkheads, trashracks, gates, valves, etc.). Inspection methods should improve data quality and reduce inspection time.
 - c. Consider alternative materials or techniques to improve corrosion protection for existing structures and equipment.
5. Mechanical equipment–turbine runner and wicket gates
 - a. Develop or improve existing tools to recommend effective operational limits that can distinguish erosive (damaging/ metal or material loss) cavitation from non-erosive cavitation.
 - b. Integrate detection tools into existing Supervisory Control and Data Acquisition (SCADA) or machine condition monitoring systems.
 - c. Improve cavitation, inspection, and repair methods for turbine runners that are cost effective, minimize outage time, and are durable and repairable.
6. Mechanical equipment–auxiliaries
 - a. Consider alternative materials or techniques to improve corrosion protection for auxiliary systems.
 - b. Improve or advance inspection methods for auxiliary systems (e.g., cooling water; heating, ventilation, and air conditioning [HVAC]; fire protection; oil piping, and equipment systems). Inspection methods should improve data quality and reduce inspection time.
7. Mechanical equipment–generators
 - a. Compile information on best practices or guidelines on rotor cracking and loose poles from industry.
8. Mechanical equipment–shafts and bearings
 - a. Improve oil level measurement accuracy and robustness for unsteady oil reservoir depths, hydraulic conditions, or difficult applications during unit operation.
 - b. Identify or consolidate information for oil quality standards (viscosity, temperature, moisture, contaminants) and performance in Reclamation’s powerplants.
 - c. Consolidate information on oil containment and leak detection for different oil systems.
 - d. Environmentally friendly lubricants–Determine the applicability and longevity of greaseless technologies and environmentally friendly lubricants to Reclamation’s powerplant operations.

3.2.2. Pumping Plants

Description

Examine and develop tools, methods, practices and strategies to improve safety, operations and maintenance, reliability, efficiency, and outage time.

Coordination Contact

Erin Foraker

Source of Research Needs

[Research Priorities to Enhance Pumping Plant Infrastructure Sustainability](#)

Needs Statements

1. Improved pump operation, including but not limited to, monitoring techniques related to pump starts.
2. Pump Storage
 - a. Identify and implement improved operation and maintenance philosophy to ensure long term sustainability of pump storage facilities
 - b. Identify, demonstrate, and enhance pump storage attributes that make it a cost-effective utility scale option for grid energy storage that supports an increasing amount of variable generation.
3. Buried and encased pipe
 - a. Research and develop longer service life interior pipe coatings that can be applied at low temperatures and high humidity.
 - b. Review and reassess uses of non-corrosive materials, such as polyvinyl chloride, for buried and encased pipe.
4. Investigate nondestructive inspection tools, such as ultrasonic testing, to improve efficiency and effectiveness of inspections in hard to access areas.
5. Pump economics
 - a. Investigate the economics of repairing versus replacing pumps and pump impellers (Reclamation's Technical Service Center [TSC] has a pumping plant assets inventory data file).
 - b. Investigate the economics of variable frequency drives regarding operational parameters, equipment and installation costs, and future utility costs.
 - c. Identify and modify machine condition monitoring techniques used for powerplants to be applicable for pumping plants.
 - d. Investigate composite materials for intake equipment, such as structural fiberglass, including lifecycle cost and benefit-cost analyses.
6. Vibration testing of exposed pipe in pump discharge basins (not in roadmap).

3.2.3. Energy Efficiency

Description

Examine and develop tools, methods, practices and strategies to improve energy efficiency at Reclamation buildings and non-hydropower facilities.

Coordination Contact

Erin Foraker

Source of Research Needs

There is no research roadmap currently available for this category.

Needs Statements

1. Explore new technologies and approaches to conduct to improve energy efficiency audits by experts and identify facility specific conservation and efficiency measures.
2. Develop, identify, and educate Reclamation personnel on best practices to achieve facility resilience, including energy and water conservation best practices, zero energy and zero water buildings.
3. Develop a methodology to maximize energy efficiency improvements prior to solar photovoltaic (PV) installations.

3.2.4. Non-Hydropower Renewable Energy

Description

Examine and develop tools, practices, and strategies for generating and using non-hydro renewable energy within Reclamation including solar, wind, geothermal, and other forms of non-hydro renewable energy.

Coordination Contact

Erin Foraker

Source of Research Needs

There is no research roadmap currently available for this category.

Needs Statements

1. Identify and develop facility scale solar training strategies to facilitate the use of solar PV at Reclamation facilities where feasible.
2. Develop expert resources to perform renewable energy assessments and assist with requests for proposals related to solar PV at Reclamation's facilities.
3. Identify and develop detailed assessments and reports of the impacts of solar PV over Reclamation water bodies.
4. Evaluate energy storage (not pump-storage) opportunities when paired with hydropower and other forms of renewable energy.

3.3. Environmental Issues for Water Delivery and Management (EN)

Improve the reliability of Reclamation water deliveries by producing effective solutions, tools, and practices that Reclamation water managers can use to address state and federal environmental compliance and court orders.

3.3.1. Water Delivery Reliability

Description

Improve the reliability of Reclamation water supplies by finding innovative means to address aquatic and terrestrial ecosystem and species needs while still meeting water delivery contracts.

Coordination Contact

Lindsay Bearup

Source of Research Needs

[Environmental Issues for Water Delivery and Management Research Roadmap](#)

Needs Statements

1. Operations strategies for flow hydrographs to improve ecological resiliencies (e.g. ecosystems, groundwater recharge, biodiversity).
2. Quantify ecosystem services related to environmental flows.
3. Develop best practices to implement adaptive management for operations to support environmental restoration.
4. Operation strategies to reduce stranding of aquatic organisms during low and high flows.

3.3.2. Invasive Species

Description

Develop and improve techniques for prevention, early detection and monitoring, control, and for determining the impacts of invasive species that consume Reclamation water supplies, impede Reclamation water deliveries, or harm threatened or endangered species.

Coordination Contact

Sherri Pucherelli

Source of Research Needs

[Invasive Mussel Research Roadmap](#), Environmental Issues for Water Delivery and Management Research Roadmap

Needs Statements

1. Prevention
 - a. Optimize invasive species prevention methods such as watercraft inspection and decontamination (WID), by developing vector modeling to prioritize WID locations.
 - b. Develop technologies to prevent the transport of invasive species from one location to another.
2. Early detection and monitoring
 - a. Develop invasive species risk assessments to prioritize monitoring and other efforts by increasing knowledge and understanding of factors that limit or promote establishment and population growth.
 - b. Optimize existing sample collection and analysis methods, and develop new methods for invasive species detection, including molecular methods and automation.
 - c. Develop monitoring protocols to apply to rapid response scenarios and to assess efficacy of control/ eradication efforts.
3. Control
 - a. Develop target specific, environmentally-friendly control methods including biological and genetic control options for the management of invasive species in reservoirs.
 - b. Evaluate and develop control tools to prevent invasive species impacts at hydropower plants and other critical infrastructure.
4. Impact assessment
 - a. Increase the knowledge and understanding of ecological and economic impacts of invasive species in the western United States.

3.3.3. Water Quality

Description

Develop and advance tools and practices that Reclamation has the mission responsibility and authority to use in managing water quality issues that are (1) linked to reclamation operations and (2) could impact the reliability of Reclamation water deliveries if not addressed.

Coordination Contact

Mike Horn

Source of Research Needs

[Environmental Issues for Water Delivery and Management Research Roadmap](#)

Needs Statements

1. Improve understanding of operational effects on water quality in flow releases, and in-reservoir processes.
2. Develop or improve methods to predict, manage, and monitor effects of hydrologic variability on water quality.
3. Understand impacts of external anthropogenic influences such as fires on reservoir water quality

3.3.4. Sediment Management

Description

Develop and improve sediment management solutions and tools that improve the reliability and sustainability of water deliveries from Reclamation reservoirs and associated river systems and improve habitat conditions for threatened and endangered species.

Coordination Contact

Jennifer Bountry

Source of Research Needs

[Environmental Issues for Water Delivery and Management Research Roadmap](#)

Needs Statements

1. When augmenting sediment downstream of dams, improve monitoring methods to track sediment below reservoirs and better understand downstream channel morphology and habitat complexity response.
2. Improve capability of numerical models to predict responses from sediment management options in reservoirs.
3. Develop indirect methods to estimate reservoir sedimentation. ++
4. Develop more cost-effective methods for removing sediment in reservoirs to maintain or increase lost storage. ++
5. Improve quantification tools for estimating effects from large scale fires on sediment production and associated river morphology or reservoir sedimentation response. Applies to water quality impacts (e.g. turbidity) from fires as well.*

*Note: A workshop is being planned in spring 2021 to further develop research needs for wildfire resource management issues related to reservoir operations, habitat availability, and water quality.

3.3.5. River Habitat Restoration

Description

Develop and improve aquatic habitat management solutions and tools that improve the ability to comply with regulatory requirements or mitigation measures assigned to Reclamation programs including channel improvements, floodplain connectivity, channel complexity, and riparian vegetation enhancement.

Coordination Contact

Connie Svoboda

Source of Research Needs

[Environmental Issues for Water Delivery and Management Research Roadmap](#)

Needs Statements

1. Develop alternatives to improve fish screen performance or that eliminate the need for fish screens.++
2. Improve upstream and downstream fish passage at dams.++
3. Improve understanding of species survival through large river systems.
4. Improve detection and tracking of movement and migration of individuals and/or species
5. Evaluate post-construction performance of rehabilitation projects through engineering and fisheries assessments.
6. Better understand effects of ecohydraulics on habitat availability, connectivity, and food webs for species of concern.
7. Improved understanding and confidence in the ability of numerical models to represent field condition hydraulics surrounding in-channel habitat features.

3.4. Water Operations and Planning (WP)

Develop solutions and tools that help Reclamation water managers make effective reservoir and river system operational and planning decisions. Improve the integration, evaluation, understanding, and presentation of critical data and information.

3.4.1. Water Supply and Streamflow Forecasting

Description

Develop and improve solutions and tools to forecast and monitor water supplies, including hydrologic events, and water demands.

Coordination Contact

Ken Nowak

Source of Research Needs

[Short Term Water Management Decisions](#)

Needs Statements

1. Develop techniques to extend or improve skill of temperature and precipitation forecasts at the seasonal time frame.++
2. Investigate new technologies and methods for monitoring/modeling snowpack conditions (e.g. snow water equivalent [SWE], snow depth, and snow extent) to improve water supply forecast skill. This may include investigations for new

measurement technologies, processing or modeling of datasets, and evaluation of water supply forecast skill improvement.

3. Develop techniques and workflows to automate data acquisition and usage in response to increasing forecast frequency and decreasing latency.
4. Explore possible hydrologic model performance enhancements by leveraging new or additional data for model calibration and forcings (e.g. Gridded Meteorological Ensemble Tool [GMET])

3.4.2. Water Operations Models and Decisions Support Systems

Description

Develop and improve reservoir/river system operations and planning models and decision support systems in order to more optimally manage water delivery and use for Reclamation.

Coordination Contact

Ken Nowak

Source of Research Needs

There is no research roadmap currently available for this category.

Needs Statements

1. Develop approaches and tools to support and improve real-time, collaborative, multi-objective water management decision making/operations.
2. Develop approaches and tools to support and improve long term planning for changing or uncertain future hydrologic conditions.
3. Develop approaches to utilize new or improved data with existing models toward enhanced operational outcomes.
4. Develop or explore decisions support tools and operational paradigms that leverage or pair with ensemble forecast products.
5. Explore opportunities for improved planning and operations that can leverage increasing access to high performance computing resources.
6. Explore opportunities to link or better integrate models and decision support systems with related models (e.g. operations, sediment, and water temperature).

3.4.3. Open Data

Description

Develop methods and tools to improve management of Reclamation’s water and related data to make it more comparable across locations, more easily found, and more shareable, both within Reclamation and with other agencies, stakeholders, and the public. Reclamation’s Open Water Data Program has developed the Reclamation Information Sharing Environment (RISE, available at <https://data.usbr.gov/>), a platform for publishing Reclamation’s mission-related data. Proposing teams should pursue projects that leverage data published in RISE, facilitate use and expansion of RISE, and/or complement RISE.

Coordination Contact

Allison Odell

Source of Research Needs

There is no research roadmap currently available for this category.

Needs Statements

1. Develop and demonstrate tools that leverage RISE data to enhance decision support frameworks and information visualization in support of engagement, communication, and collaboration amongst Reclamation customers, stakeholders, other agencies, and the general public.
2. Investigate methods to facilitate adoption and expand utilization of RISE and/or contribute to expanding RISE data publication capabilities. This may include investigation of methods for publishing data types that are not currently represented in RISE (e.g. large, complex, multi-dimensional, or novel datasets) or for which RISE could provide better data services. This could also include development of data standards, data formatting tools, or data management methods to enable or expand compatibility with the RISE system.
3. Identify and evaluate how emerging technologies and trends related to data discovery, integration, and use, such as enhanced metadata and learning algorithms (e.g. web 3.0, semantic web, natural language processing, machine learning, etc.), can be effectively applied in Reclamation data management and dissemination.

3.4.4. Climate Change and Variability

Description

Develop methods and tools to increase adaptive management and flexibility in the planning, design and operations of Reclamation's facilities in a variable and changing climate, including management of droughts and floods.

Coordination Contact

Ken Nowak

Source of Research Needs

[Addressing Climate Change in Long Term Water Resources Planning and Management](#)

Needs Statements

1. Develop tools and resources to support informed use of climate model projections in water management applications.
2. Develop methods and basis for estimating extreme meteorological and hydrologic event possibilities, deterministically or probabilistically, in a changing climate.
3. Identify risks posed by climate change and extreme weather, to efficient and continuous operation of water and power infrastructure, and potential adaptation strategies.
4. Explore and quantify uncertainty associated with future water availability projections developed from climate model output (e.g. role of climate model, emission scenario,

and downscaling in uncertainty). Develop communication resources for conveying findings to decision makers.

3.5. Developing Water Supplies (WS)

Develop, enhance, and protect water supplies for Reclamation stakeholders with new technologies, solutions, and practices that expand, liberate, or conserve water supplies.

3.5.1. Advanced Water Treatment

Description

Develop technologies, methods, tools and approaches to advance the treatment of impaired water sources that allow Reclamation to better utilize existing supplies, increase existing Reclamation supplies through augmentation, or prolong existing Reclamation supplies by expanding or developing non-traditional supplies from an outside source such as impaired groundwater or surface water.

Coordination Contact

Yuliana Porrás-Mendoza

Source of Research Needs

[Desalination: A National Perspective](#) and [Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater](#)

Needs Statements

1. Enhance water management decision making by quantifying the non-monetized costs and benefits of potable and non-potable water reuse compared with other water supply sources.
2. Reducing the environmental impact of water treatment by:
 - a. Reducing chemical usage.
 - b. Mitigating biofouling.
 - c. Improving concentrate management.++
3. Develop improved techniques and data to consider hazardous events or system failures in risk assessment of water reuse.
4. Develop innovative new water treatment systems (membranes, systems, processes, etc.) for treatment of impaired water for various uses (potable, industrial, storage, municipal, agricultural, etc.).
5. Develop models for implementation and management of various water sources in need of one or more treatment for one or more end use.
6. Develop innovative new materials, membranes, and/or systems and processes for treatment of impaired water.

7. Development of water-energy nexus research in the following areas:
 - a. Coupling of renewable energy sources with water treatment processes.
 - b. Modeling of energy efficiency for innovative new water treatment processes or combination of existing water treatment processes.
 - c. Treatment and use of produced/fracking water for increase in water supply and energy production.

3.5.2. Groundwater Supplies

Description

Develop and improve solutions and tools that advance and optimize groundwater storage and conjunctive groundwater/surface water storage and use for Reclamation projects.

Coordination Contact

Jennifer Johnson and Ken Nowak

Source of Research Needs

[Brackish Groundwater in the United States](#) and [Ongoing Research Needs: Groundwater-Surface Water Interaction](#)

Needs Statements

1. Groundwater quality data needs
 - a. Occurrence and distribution of groundwater
 - b. Hydrogeologic characterization.
 - c. Geochemistry
 - d. Brackish groundwater use.
 - e. Brackish groundwater sustainability
2. Groundwater-surface water interaction
 - a. Summarize relevant data and overcoming data gaps
 - b. Models and processes used to evaluate groundwater-surface water interaction in regulated river systems

3.5.3. Agricultural and Municipal Water Supplies

Description

Develop and improve solutions and tools that automate, measure, and deliver agricultural water resulting in liberated water or a cost savings for Reclamation or its stakeholders. Research technologies that enhance water availability through weather modification or other novel approaches.

Coordination Contact

Yuliana Porras-Mendoza

Source of Research Needs

There is no research roadmap currently available for this category.

Needs Statements

1. Research to understand winter orographic cloud seeding effectiveness and impacts.

3.5.4. System Water Losses

Description

Develop and improve solutions and tools that conserve water and/or reduce water losses, in Reclamation water storage and delivery systems.

Coordination Contact

Yuliana Porras-Mendoza

Source of Research Needs

There is no research roadmap currently available for this category.

Needs Statements

1. Improve evaporation measurement technology that is necessary to evaluate the efficacy of evaporation suppression technologies.
2. Improve evaporation measurement data management at Reclamation reservoirs and evaluate the impact of the sustained water loss.
3. Develop new and innovative ways to reduce the loss of water via evaporation at reservoirs and optimize systems to maintain water at Reclamation reservoirs in order to meet water delivery requirements.