Proposed FY14 Bureau of Reclamation activities to contribute towards strengthening the scientific understanding of climate change impacts on freshwater resources of the United States

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Background:

An August 2011 Report to Congress on *Strengthening the Scientific Understanding of Climate Change Impacts on Freshwater Resources of the United States* (Report) makes 25 review findings related to Section 9506 of PL 111-11 and recommends 6 next steps. The Report emphasizes that effective management of the Nation's water resources will require meaningful action on hydroclimatic observational and modeling systems. Moreover, continued vigilance and effort will be required to sustain and enhance vital observation and modeling systems that are currently in place and operating effectively over a period of years. The report recommends that federal agencies consider amending existing programs and policies to incorporate these actions and consider these actions in future budget planning.

Proposal:

The Bureau of Reclamation has expertise, water management needs and makes contributions in virtually all of the areas outlined in the Report's next steps. Reclamation is well poised to make significant contributions in the following areas:

- Enhanced water management climate projections: Including new downscaling, hydrologic modeling and decision maker engagement.
- Data stewardship: Proposed river restoration and water storage and delivery pilot projects, or more general data provision activities.
- Climate change training: Provide water managers with a solid foundation in climate change information and issues.

All of the Report's recommended next steps are copied below, with a brief proposal on how Reclamation could contribute through a FY2014 activity (in blue). As the choices are refined, more detailed proposals can be developed.

Key next steps:

1) **Strengthen observational data systems for fresh-water resources and climate change.**
   - *Strengthen existing efforts, including the Water Census, through enhancements to the hydroclimatic observational network identified in Review Element 1 of this report. Information that is critical from a health, safety, and welfare perspective should be given priority, while considering the data needs of land, water and environmental resource managers. Effects on water resources from energy extraction and production, and carbon sequestration (both geologic and biological) need increased emphasis.*

Migration to a Reclamation-wide Data Management Solution

Reclamation recognizes that water data management plays a central role in managing water in the west, and will strengthen the U.S. Geological Survey (USGS) Water Census. Many Reclamation projects provide information about current water supply, storage and delivery operations to stakeholders and partners, typically through one or more websites. However, Reclamation offices take different approaches to describing this information and providing it to the public. Further, various agencies within the same river basin do not use the same data standard, metadata or data stewardship methods.

The Report identifies the need for improved interagency coordination, improved monitoring for use in adaptive management, and making data more widely available information for streamflow, reservoir and lake data, groundwater level, soil moisture, evapotranspiration, precipitation, snowpack, glaciers, water-quality, wetlands, consumptive use and environmental flows. As part of its water and ecosystem management activities, Reclamation collects observations for many of these data types and in FY14 proposes to apply data stewardship standards towards ensuring data quality and metadata descriptions and to make these observations and their metadata widely available using community-accepted water data standards and web services.

Through a series of pilot projects, Reclamation proposes to facilitate agreement across all water management offices, partner agencies and stakeholders to adopt a common data and metadata standard for describing water supply, storage and delivery. This will allow creation of a data portal thru which anyone can find and retrieve standard water supply and delivery data. Following the pilot projects, this project would seek to extend the data standard development and adoption for water data across Reclamation that provides an integrated, customer-facing water data portal.

Importantly, this effort will not require any office to change the way it currently displays these data to the public. The common data standard will be implemented as a background translator of existing data, and will allow creation of a common data portal in addition to the current web displays. Data collection will not be centralized. The portal will simply link to and translate data to a standardized format from each of the agency's servers.

Reclamation Climate Change Monitoring

As outlined in Reclamation's April 2011 *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011* report, significant freshwater changes are expected over the next century as the climate changes. To monitor these expected changes and sustainably apply adaptive management, key improvements in Reclamation's environmental monitoring program are needed. For example, observations such as evaporation over reservoirs and rivers, along with evapotranspiration over riparian and agricultural areas will be valuable for prediction model development and management practice optimization.

Long-term monitoring networks are critical for detecting and quantifying climate change and its impacts. Continued improvement in the understanding of climate change, its impacts and the effectiveness of adaptation or mitigation actions requires continued operation of existing long-term monitoring networks and deployment of improved sensors. Monitoring needs to focus on locations that describe the climate signal, for example, upstream and downstream from major water-management infrastructure or in vulnerable ecological reaches.

To this end, Reclamation proposes to perform an observational gap analysis to identify needed additional observational capabilities to assure sustainable adaptive water management and implement a plan to address those monitoring needs. Example key observations that may be needed to monitor climate change may be temperature, precipitation, streamflow, snowpack, evaporation and groundwater. The relative importance of quality assurance, observational uncertainty limits, homogenization of data sets, and intercalibration of methods and procedures on water management decision making in a changing climate will also be considered.

Pilot River Restoration Data Stewardship Demonstration

A river restoration pilot data stewardship test project is proposed for FY14, focused on one river restoration program per region. Reclamation's investment in river restoration is very large and increasing, and the data collected in these activities are often critical to environmental compliance and the continued operations of Reclamation projects.

A river restoration program involves many partners and stakeholders, making the planning, collection, sharing and documentation of data challenging. Each program involves many kinds of data important to decision making, e.g., hydrology, geomorphology, water quality, biology, lands, geographic information systems, project operations, etc. They are natural test beds for discussions across several

resource data classes. The river restoration programs in the pilot test are of a scope and scale that both requires and can support sophisticated data stewardship.

While the pilot test of the policy would not require data acquisition and management plans for data collection efforts outside of these river restoration programs, it is critical that a Reclamation data stewardship team be formed and include representatives from the other data classes to contribute experience and expertise to river restoration data stewardship and to consider the development of training, tools and methods that might help data management across the agency. It is this conversation that provides the greatest corporate value to the agency.

Pilot Water Storage and Delivery Data Stewardship Demonstration

A water storage and delivery data stewardship pilot test project is proposed to be conducted on a major river basin, possibly the Columbia. Reclamation will lead this effort with the provision of its water storage and delivery observations and metadata via eXtensible Markup Language based (XML) web services that are defined by an XML Schema. Further, Reclamation will invite river basin data stewardship partners to collaborate towards providing a basin-wide example for the availability and utility of water storage and delivery observations for all basin facilities in a consistent manner via web services.

Targeted information will be surface water storage in rivers, reservoirs and lakes, and water delivery, release and flow data for rivers, canals, intake structures and dams. An inventory of existing watershed-wide water storage and delivery data sources, formats and metadata will help to identify gaps and needs, and a survey of data exchange approaches and technologies will be used to identify a leading approach that is broadly accepted throughout the sector.

A successful water storage and delivery data stewardship pilot project would provide information valuable for basin-wide climate assessments, coordinated adaptive management endeavors, and would flow into and improve science investigations and forecasting efforts.

- *Conduct ongoing and sustained analyses of hydroclimatic data to identify emerging trends and patterns and to develop new insight into hydroclimatic variability.*

Enhanced Hydroclimate Analyses

In April 2011, Reclamation published its first 5-year *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011* report highlighting impacts of climate change to western water resources as directed by the Omnibus Public Land Management Act of 2009 (Public Law 111-11) Subtitle F – SECURE Water. The report to Congress represents the first consistent and coordinated assessment of risks to future water supplies across eight major Reclamation river basins.

Reclamation proposes to build on this report by developing enhanced methods and exploring new data types to conduct ongoing and sustained hydroclimate analyses to identify emerging trends and patterns and implement adaptation strategies towards sustainable water management. This may be combined with an observational/modeling gap analysis for optimal utility. Analysis techniques will be explored that allow evaluation of climate adaptation alternatives over a wide range of future scenarios which could improve system flexibility. This will require inclusion of existing and potential future uses of water resources in the analysis. Finally, advanced hydroclimate analysis approaches that support adaptive management (such as Bayesian networks), where decisions are made sequentially over time and allows adjustments to be made as more information is known, will also be explored.

2) **Prioritize observational systems that fill important gaps in understanding water supply reliability.**
   - *Enhance collection of water-use information, including provision of timely information on withdrawals and return flows (quantity and quality) from surface and groundwater resources and information on withdrawals and consumptive use by sector.*

Consolidation of Water-Use Information and Basin Study Results

Reclamation's Basin Studies Program works with state and local partners in individual watersheds to evaluate future water supply and demand imbalances in a changing climate. They include assessments of existing and future supplies and demands including impacts of climate change, and analyses of how a basin's existing water and power operations and infrastructure will perform in response to projections of future water supplies and demands.

Reclamation proposes to build on the Basin Studies partnerships to (1) consolidate timely water use and water reliability information by sector, (2) identify water use and reliability information gaps and prioritize actions for mitigating those gaps, and (3) consolidate Basin Study water-use and demand projections across the 17 western states to provide a large-scale view and enable prioritization of western water challenges.

Water Demand Scenario Tool

Reclamation's Basin Studies program and West Wide Climate Risk Assessments have collected substantial information on water-use information and demands, including observed and projected evapotranspiration demands (observational validations, enhanced modeling).

Reclamation proposes to consolidate this water-use and demand information, and develop a demand scenario development tool to assist decision makers in developing future demand scenarios (agricultural, environmental, etc.). The tool would provide visual feedback as the user manipulates various demand scenarios, for example, population growth projections. Reclamation will seek partnerships in the development of this tool for improved applicability across agencies and stakeholders.

- *Implement the proposed National Streamflow Information Program and the National Groundwater Monitoring Network, both of which are authorized in PL 111-11.*

Groundwater Monitoring Network

Sustainable groundwater management is currently constrained by the lack of a nationally integrated groundwater monitoring network focused on providing water level and water quality data. The need for a national groundwater monitoring network has been recognized by numerous water resource agencies. To address this concern the Subcommittee on Groundwater (SOGW) was established in 2007 as an ad-hoc committee under the Federal Advisory Committee on Water Information (ACWI). The SOGW and the U.S. Geological Survey established the National Ground Water Monitoring Network (NGWMN) to provide information needed for planning, management, and development of ground-water supplies to meet current and future water needs and ecosystem requirements. This will be accomplished by aggregating suitable ground-water data from local, state and federal organizations.

Reclamation performs substantial groundwater monitoring around agricultural areas focused on subsidence, salinity, drainage, remediation and groundwater banking issues. It is proposed that these datasets be consolidated with standard metadata and provided to the National Groundwater Monitoring Network. This work would involve identifying available Reclamation groundwater information, partnering with agencies and stakeholders to agree on common data definitions, formats and metadata, and then delivering these data to the NGWMN.

Benefits for participating in this groundwater monitoring network include access to similar data from partners that may improve scientific understanding and decision making.

- *Develop and implement a national lake/reservoir level and contents data network.*

Lake/Reservoir Network

Lake and reservoir level reflects complex water exchanges that, in part, reflect climate changes occurring in the region. Lake and reservoir water storage, which depends on water level, is an easily available source of water for many sectors of economy such as agriculture, domestic and industrial water

supply, hydropower, water transport and others. Therefore, a national lake/reservoir level data network is critical to understanding, assessing and mitigating the impact of climate change on water resources.

Reclamation has substantial experience and investment in reservoir monitoring including storage, delivery and uncertainty issues. It is proposed that Reclamation either lead in the development or assist the U.S. Geological Survey to consolidate lake and reservoir information, including standard metadata and toward development of the national lake/reservoir level data network. This work would involve partnering with various water management agencies and stakeholders, agreeing on common data definitions, formats and metadata, and then to deliver these data in a timely fashion. If Reclamation leads this effort, then there may be need to develop a national data portal, and to work with partners to create web service links to their datasets.

Benefits of this lake/reservoir network would be significant, as it would provide scientists with critical information to improve process understanding and calibrate models, and would provide decision makers with key information about multi-agency regional water availability information.

- *In partnership with private industry, conduct research on new monitoring technologies, including sensors, data transmission, automated quality assurance, and remote-sensing technologies.*

3) **Improve water-quality and ecosystem monitoring systems.**
   - *Implement the National Water-quality Monitoring Network, which is supported by the Advisory Committee on Water Information and is consistent with the National Ocean Council's Strategic Action Plans.*
   - *Enhance interagency efforts and support States to monitor and improve mapping of wetland areas and habitat quality on a seasonal basis.*

River Restoration Science

River restoration is central to Reclamation's mission to assist in meeting the increasing water demands of the West while protecting the environment and the public's investment in these structures. River Restoration encompasses set of activities that help improve the environmental health of a river through expanded habitat, reduced stream bank erosion, improved water quality, or achieving a self-sustaining, functional flow regime that does not require periodic human intervention. At its heart, river restoration is a real-world science experiment that uses channel modification, wetland construction, bioretention, infiltration basins and engineered structures to improve habitat. Successful restoration projects include careful river system studies including climate, hydraulics, sediment transport patterns, etc.. Researchers evaluating restoration projects have found that many of these projects subsequently fail because the projects were not designed with a sufficient scientific basis.

Therefore, it is proposed that Reclamation establish a river restoration research program, where science and engineering expertise and experience can be systematically shared and applied towards successful restoration projects. The program would be a Reclamation-wide competitive, merit-based applied research and development program that is focused on innovative solutions for Reclamation's river restoration efforts.

- *Implement a waterborne disease tracking network, including all appropriate ancillary data.*

4) **Strengthen links between hydroclimatic observational data systems and climate models; improve data management, acquisition, analysis, and reporting.**
   - *Link monitoring, observational systems, climate model outputs and other data systems, to update and improve hydroclimatic statistics that support high-priority water management decisions (particularly related to water supply reliability and quality).*

Piloting Climate Projection Downscaling Methods and Development of Advance Hydrologic Modeling Approaches

Since 2007, Reclamation has collaborated with Lawrence Livermore National Laboratory, Santa Clara University, U.S. Geological Survey, Scripps Institution of Oceanography, U.S. Army Corps of Engineers, and Climate Central to support adaptation planning by serving downscaled climate projections for the continental United States and hydrologic projections for the western United States. FY12-13 activities will involve applying these methods to new global Coupled Model Intercomparison Project climate projections, and collaborating with archive partners to develop hydrologic projections for the continental United States.

This FY14 proposal involves Reclamation continuing the collaboration. There would be two key areas of activity: (1) broker research between collaboration partners and other entities (e.g., National Center for Atmospheric Research, U.S. Geological Survey, Climate Science Centers, Regional Integrated Sciences and Assessments, various universities) to support development and piloting of improved climate projection downscaling techniques, and (2) broker research involving these same parties to develop advanced hydrologic models, thereby improving the reliability of hydrologic projections under climate change. These projections would be available at higher resolutions, and include more comprehensive uncertainty assessments than the previous generation, and would be made widely available for use by water management partners and stakeholders.

Hydroclimate Projection Scenario Tool

Reclamation's efforts towards the West Wide Climate Risk Assessment and the *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011* report has resulted in the availability of a large database of hydroclimate projection knowledge. In fact, Reclamation recently posted its bias corrected and downscaled climate and hydrology projection data including 53 daily downscaled climate projections over the contiguous United States, and 112 hydrologic projections over the western United States.

Reclamation's hydroclimate projections are widely used by partner agencies and stakeholders. However, their utility is limited to sophisticated users who can download and analyze these large datasets. Therefore, to make these projections more accessible to decisions makers and stakeholders, it is proposed that Reclamation develop a web-based user-friendly tool to translate climate and runoff data presented on Bias Correction and Spatial Disaggregation (BCSD) website into graphs or maps developed on-the-fly. Users could navigate to their region of interest, request customized graphics, and receive straightforward information on projected hydrologic changes and uncertainties. The proposed web site would offer data applications and tools for assessing vulnerability of programs or facilities to climate change, and could include similar projections made by partner agencies.

North American Water Program

The North American Water Program (NAWP) is being proposed by the hydroclimate science community as an interdisciplinary, international, and interagency integration of North American hydroclimate observation and prediction resources to advance water resource prediction and management skill. The nation clearly needs a focused interagency research program collaboration to move toward water security and sustainability.

The NAWP objective is to entrain, integrate and coordinate the vast array of interdisciplinary observational and prediction resources available to significantly advance skill in predicting and managing changes in North American water resources, as an integral part of the global climate system. The NAWP mission is to measure and predict North American energy and water variations, trends and extremes through improved observations and prediction, thereby providing the scientific underpinnings of future climate services.

It is proposed that Reclamation take a leadership role, in collaboration with a wide array of partners to plan and implement the NAWP program. Specifically, it is proposed that Reclamation take responsibility for leading the third NAWP challenge, *science informed water management*. By helping to lead and implement the NAWP, Reclamation will be directly shaping interagency research investments towards its

water management and decision making goals. Reclamation will further benefit through leveraging the resources of the research community towards a sustainable environment, and water and power deliveries.

- *Build on the initial foundation established by the Integrated Water Resources Science and Services activity to expand and encourage the use of consistent data standards across agencies and with non-governmental partners and other ways to integrate existing data into more comprehensive water information systems.*

See data stewardship proposals above.

- *Develop new and improved models (both statistical and deterministic) for assessing hydroclimatic data, developing design conditions, and forecasting likely future conditions for expected scenarios.*

See above proposal for enhanced climate projections for water management.

- *Develop guidance for water managers on appropriate use of probabilistic projections and model outputs.*

Develop and Deploy Training on Appropriate Use of Climate Projections for Long-Range Water Resources Planning

Over the past few decades the research community has demonstrated approaches for conducting climate change impacts assessments on water and environmental resources. Despite having such demonstrations, federal and non-federal agencies are challenged by having few technical practitioners on staff who understand these methods and can adapt them to agency studies.

In FY12-13, Reclamation is beginning to address this challenge, implementing training pilots through collaboration with the University Corporation for Atmospheric Research COMET program, which over the last 20 years has developed hundreds of training modules for National Weather Service meteorologists. This collaboration builds on COMET's expertise in both classroom, online and distance learning to create training to help water managers understand and incorporate both long-term climate projections and shorter term forecasts into water project planning and operations. Participants and contributors to this effort are the Climate Change and Water Working Group agencies (U.S. Army Corps of Engineers, National Oceanographic and Atmospheric Administration (NOAA), Environmental Protection Agency and U.S. Geological Survey) and the Regional Integrated Sciences and Assessments (RISAs).

This FY14 proposal would move Reclamation from pilot to larger-scale deployment of training resources. Key areas of activity include: (1) working with training program partners to expand the training curriculum beyond the focus of FY12-13 (surface water hydrology and crop water demands) to include courses focused on other resource sectors and management objectives (e.g., groundwater, water quality, ecosystems, flood protection), (2) work with Climate Science Centers, RISAs and NOAA's Climate Prediction and Projection Program to synthesize FY12-13 evaluations of new global Coupled Model Intercomparison Project climate projections and their downscaled translations over the United States, with the goal of diagnosing this projection information for credibility and applicability in water and environmental resources planning, (3) apply findings from (2) to inform the design of appropriate course modules guiding appropriate use of climate projections for various planning and management situations.

5) **Support the establishment of an interagency climate data portal and provide access to high priority water-related datasets.**

- *Promote interagency coordination of diverse data and define the architecture of data systems for freshwater resources to facilitate improved access to these data through a single portal. As a part of the portal, provide for user feedback, including recommendations for improvements or modifications.*

Climate Data Portal

Through efforts developing the West Wide Climate Risk Assessment and the *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011* report, Reclamation has developed a large database of hydroclimate projection knowledge. In fact, Reclamation recently posted its bias corrected and downscaled climate and hydrology projection data including 53 daily downscaled climate projections over the contiguous United States, and 112 hydrologic projections over the western United States.

These core water data projections and associated hydrostatistics that have been developed by Reclamation are not readily available to water resource managers at a single site. The proposed portal would offer data applications and tools for assessing vulnerability of programs or facilities to climate change, and would include similar projections made by partner agencies.

The National Oceanographic and Atmospheric Administration is developing a prototype portal in coordination with the National Climate Assessment. It is additionally proposed that Reclamation provide information to the portal using data standards and mechanisms that have been agreed upon nationally and internationally. An example is leveraging GEO standards for data interchange and interoperability.

6) **Strengthen coordination to improve the quality and accessibility of freshwater data systems including technical outreach and support to stakeholders and decision-makers.**
   - *Request that the Subcommittee on Water Availability and Quality (SWAQ) monitor progress on implementing the findings and recommendations of this report and provide annual updates to the National Science and Technology Council and member agencies, and to non-Federal partners.*
   - *Promote interagency coordination and cooperation to implement the National Water Census (http://water.usgs.gov/wsi/) and Integrated Water Resources Science and Services (National Oceanic and Atmospheric Administration, 2011k).*

Enhanced Climate Change and Water Working Group

In 2008, Reclamation led the formation of the interagency Climate Change and Water Working Group (CCAWWG) to work with the water management community to understand their needs, and to foster collaborative efforts across the federal and non-federal scientific community to address their needs in a way that capitalizes on interdisciplinary expertise, shares information and avoids duplication. However, there is not presently a national forum for fostering communication and coordination for climate change and water resources adaptation-related work among the full range of relevant Federal agencies (National Freshwater Action Plan, 2011).

Therefore, it is proposed to upgrade the authority and profile of the CCAWWG to fill this need. The CCAWWG coordination efforts can be expanded to include: (1) federal agency coordination; (2) linkage to science and research; (3) engagement in different regions of the country with state, local and tribal governments; and (4) participation of stakeholders and the public. The CCAWWG can also expand its efforts to include the establishment of coordinated planning processes with the capability to identify priority adaptation actions, promote their implementation, and track their progress and effectiveness.

This expanded CCAWWG effort would be performed in support of the Subcommittee on Water Availability and Quality (SWAQ), and the interagency Climate Change Adaptation Task Force.

Contributions to Integrated Water Resources Science and Services

The U.S. Army Corps of Engineers (USACE), National Oceanic and Atmospheric Administration (NOAA) and U.S. Geological Survey (USGS) signed a Memorandum of Understanding (MOU) on 11 May 2011 to address America's growing water resources challenges by addressing water information needs including the creation of high-resolution forecasts of water resources showing where water for drinking, industry and ecosystems will be available. A centerpiece of this MOU is the Integrated Water Resources Science and Services (IWRSS), whose objective is to provide the Nation with a seamless suite of consistent water resources monitoring and forecast information by integrating water science and services.

In FY14, it is proposed that Reclamation become an active member of the collaboration by participating in project plan development, exchange of technical information, tools and services, joint studies, research and development activities of mutual interest, joint educational and communications activities to advance the understanding of water resources planning and management, and exchange visits and work details of individuals sponsored by all agencies who are engaged in water resources projects of mutual interest.

Benefits to Reclamation include: (1) enhancing interagency coordination on water science, services, and tools that will help Reclamation more effectively leverage interagency efforts and resources, (2) more direct advocacy for interagency tool and data development that address Reclamation needs, and (3) expedited access to Reclamation observations, tools and operations will benefit water information, forecasting and decision making by other agencies.

Contributions to the National Water Census and the National Climate Assessment

The U.S. Geological Survey is developing a National Water Census (NWC) that quantifies, forecasts, and secures freshwater for America's future. In parallel, the U.S. Global Change Research Program (USGCRP) is conducting a National Climate Assessment (NCA) that is a status report on climate change science and impacts.

It is proposed that Reclamation develop focused product contributions to the NWC and the NCA based on Reclamation's Basin Studies and West-Wide Climate Risk Assessments. Reclamation would develop an ongoing analysis of scientific understanding of climate change impacts, risk and vulnerability for water management decisions and policies. Reclamation could also provide systematic evaluation of progress towards reducing water management risk, vulnerability and impacts. Finally, Reclamation would inform NWC and NCA on the implications of alternative water management adaptation and mitigation policy options.

- *Encourage the Advisory Committee on Water Information, an existing Federal Advisory Committee, to establish a new subcommittee or other appropriate mechanism, to solicit and consider input from the public and stakeholders on matters related to freshwater resources and a changing climate and relay these views to Federal water data program managers and the SWAQ.*
- *Fully engage States, Tribes, local agencies, and interstate organizations, most of whom have water-resources management responsibilities, in the implementation of the findings in this report.*

See enhanced CCAWWG proposal.