A Drought Early Warning System for the 21st Century:
The National Integrated Drought Information System (NIDIS)
Working Draft Report

EXECUTIVE SUMMARY
(This section will be in the form of a letter from the governors – spring 2004)

INTRODUCTION AND BACKGROUND

For years, farmers and ranchers, tribes, land managers, scientists, economists, business owners, conservationists and wildlife managers, municipalities, counties, states, regional entities, and the federal government have grappled with the far-reaching consequences of drought. Numerous papers, reports, and books have documented the impacts of drought. They have pointed out repeatedly that drought planning and proactive mitigation programs may well reduce the need for huge federal emergency relief expenditures in drought-stricken regions—usually to assist farmers and ranchers and rebuild local economies. They have also indicated that planning and proactive mitigation may lessen conflicts over competition for water during drought.

Unfortunately, the United States does not currently have a national policy for drought with planning and preparedness at its core. Consequently, we approach droughts in an ad hoc, response-oriented manner, i.e. through crisis management, rather than through coordinated preparedness strategies designed to mitigate the impacts of drought. This is in contrast to other natural disasters, such as floods, hurricanes and earthquakes, for which the Stafford Act was enacted to lay out the roles and responsibilities for the various Federal agencies, including designating the Federal Emergency Management Agency (FEMA) as the federal lead.

Why is drought treated differently? It is hard to miss the presence of an oncoming flood, hurricane or tornado, or their immediate aftermath. Droughts, however, are a creeping phenomenon, which develop slowly over large areas and an extended period of time. Recognition of droughts in a timely manner is dependent on our ability to monitor and forecast the diverse physical indicators of drought, as well as relevant economic, social and environmental impacts. The lack of a national drought policy has hindered the development of a coordinated, integrated drought monitoring and forecasting system.

Recent trends toward increased climate variability amplify the need to formulate and implement a monitoring and forecasting system to assess drought risk and to facilitate subsequent natural resource management decisions in *real-time* and *before* the onset of drought. The emergence of new tools such as the *U.S. Drought Monitor*, established in 1999 to better integrate data on current conditions has been an important advancement in drought monitoring. Likewise, the *U.S. Seasonal Drought Outlook*, which was created in 2000, is an important new tool that strives to better forecast drought. Users of this information are seeking further refined tools, which will integrate relevant and available drought data to improve monitoring, provide a better understanding of how and why

droughts occur to improve forecasts, and enhance dissemination of information while providing access at the relevant spatial and temporal scales.

Recognizing the need for improved drought forecasting and monitoring by water users and resource managers, the Western Governors' Association (WGA) approached the National Oceanic and Atmospheric Administration (NOAA) with a proposal to develop a report and recommendations proposing a vision for the National Integrated Drought Information System (NIDIS). In February 2003, NOAA Administrator Conrad Lautenbacher met with WGA Lead Governor for Drought Mike Johanns and agreed to pursue a partnership on this project. This report is the result of that effort.

VISION AND GOALS

National Integrated Drought Information System (NIDIS) Vision: A dynamic and accessible drought information system that provides users with the decision support tools needed in preparing for and mitigating the impacts of drought.

NIDIS Goals

NIDIS is intended to accomplish the following goals:

- Develop the leadership and partnerships to ensure successful implementation of an integrated national drought monitoring and forecasting system;
- Create a drought "early warning system" that provides accurate, reliable, timely, and integrated information on drought conditions at the relevant spatial scale, in order to facilitate proactive decisions that minimize the economic, social and ecosystem losses associated with drought;
- Foster a research environment that focuses on impact mitigation and improved predictive capabilities;
- Provide an "Internet gateway" with easily comprehensible and standardized products (databases, forecasts, GIS-based products, maps, etc.);
- Provide a framework to communicate, interact, and educate those affected by drought on how and why droughts occur, and how they impact human and natural systems.

INTEGRATING OBSERVATIONS AND DATA SYSTEMS

Current Observations and Data Systems

Characterization of drought requires a combination of two types of information:

1. Observations, based on instrumentation, about the current physical state of the environment and their context within the relevant historical record.
2. Documented impacts on human and natural systems that are a consequence of the physical conditions.

A sophisticated network of physical and social scientists is necessary to maintain the physical observing system, collect and analyze the data and collect and synthesize information on drought impacts.

The physical information needed to monitor drought includes observations of air temperature, precipitation, humidity, wind speed and direction, solar radiation, snow depth and snow fall. In addition, soil temperature and soil moisture measurements are far too sparse and in some settings nearly non-existent. These and related observations must meet rigorous data quality standards.

Because drought revolves around the supply of and demand for water, a parallel data structure for stream flow, lake and reservoir level, and ground water status also is required for NIDIS. With our increasing dependence on groundwater, a national system of groundwater monitoring wells is essential.

At present, the greatest unmet needs for data and information are on the smallest of physical scales: local, state and regional. Impact and physical information at these scales is almost impossible to obtain in a uniform manner across the nation at the present time. An observational network with an "adequate" spatial density should have approximately one observing site for each 400 square miles of the United States, or about 15-20 miles apart—similar to the station-density proposed by the National Weather Service for the modernization of its Cooperative Observer Network.

Drought information needs differ greatly by region. In the West, for example, snow constitutes a critical component of water supply. It is thus essential to generate and distribute the best estimates possible of the water content of snow on the ground, snowmelt, and snow pack properties such as temperature.

The Role of Remote Sensing

Each type of data involves tradeoffs and shortcomings, so all these data types must be integrated in meaningful ways. To fill important data gaps, complementary data from remote sensing, satellites, radar, aircraft, and other technologies must be explored, encouraged, and incorporated.

Working with the Private Sector

Whereas governmental agencies have shown great innovations, there is also an important role for the private sector in collection of drought data and development of new tools. Opportunities may exist in which government can set priorities, provide direction, specify needs, and then allow for a competitive and innovative private sector to meet those needs. Issues may need to be overcome or addressed when working with the private sector, for example, issues arising from proprietary information, quality control of data, consistent observational methodologies, standardization of the data, etc.

Building a Baseline of Social and Economic Observations

There is currently no systematic collection and analysis of social and economic drought impact information and data within the United States. Examples of such data could include drought-related relief payments, mental health visits in drought-stricken areas, losses of rafting guide revenues, decreases in barge tonnage, reduced hydropower production and revenues, increased groundwater pumping costs, etc. Because such information is either absent or inaccessible, social and economic costs related to drought

are underestimated by officials at all levels.

NIDIS should develop methodologies to collect and analyze the social, environmental, and economic drought impacts that occur within the United States. These methodologies will also encourage the development of impact assessments from the sectors where the drought impacts are much less known, such as the livestock, timber, energy, recreation and tourism, and environmental sectors.

Understanding the social, environmental, and economic impacts of drought will empower users and extend the comprehension of the full magnitude of drought losses and encourages local, state, and federal officials to increase efforts in drought planning and mitigation. Baseline data on drought impacts will also help to verify the cost effectiveness of risk versus crisis management approaches to drought management.

DEVELOPING NEW TOOLS

Current Tools and Needs

There are numerous federal agencies that manage drought monitoring programs. For example, USDA's Natural Resources Conservation Service (NRCS) manages snow pack information, the Corps of Engineers and Bureau of Reclamation manage reservoir storage data, NOAA manages hydroclimatic data, and Interior's Geological Survey (USGS) has groundwater and stream flow information. These programs have generally evolved independently, require separate appropriations, and, until recently, have not been available to users at a central location due to their complexity and lack of tools for integration.

NIDIS will provide an integrated drought information system that consists of tools and processes designed to bring together a variety of observations, analysis techniques, and forecasting methods to support user drought assessment and decision making. Such tools allow users to access, transform, and display basic data and forecasts across a range of spatial and temporal scales most suited to their needs. There are four basic types of drought information tools:

1) Data access tools facilitate the retrieval of data from the agencies that collect and archive it.
2) Analysis tools use raw data as input and add value through computational processes, such as data transformation, modeling, and statistical analysis.
3) Data display tools enable visualization of raw and analyzed data in ways that add value for the user. Geographic Information System (GIS) software provides the basis for examination of geo-referenced information.
4) Forecast tools are a specialized form of analysis, combining statistical properties of available observations and models of future behavior to develop forecasts.

Future Tools

An infrastructure for developing, integrating, and maintaining a suite of drought decision support tools does not exist, but is fundamental for the success of NIDIS. This

infrastructure will be built on existing institutions with complementary expertise at state, regional, and national levels.

Provided adequate funding, the development of the NIDIS infrastructure will be staged over time. Drought tools focused on environmental variables (e.g., temperature, precipitation) are currently available but not integrated with user needs, and do not constitute a complete product suite. Drought impact assessment tools and databases that gather and display drought impact information do not exist.

Benefits of New Tools

Users will interact directly with the Internet gateway, allowing rapid and continuous assessments of drought risk. Access to drought risk information will increase benefits to users since drought impacts vary by time of year. On-demand risk analysis will provide the lead time needed to implement appropriate economic strategies to reduce drought impacts.

COORDINATING RESEARCH & SCIENCE FOR NIDIS

At present there is no coordinated and integrated drought research program at the national level, despite the enormous impacts that droughts have every year on the Nation's economy, society, and the environment. In this respect, drought differs from other major natural disasters, which have sustained federal research programs and significant interagency coordination, e.g., research on hurricanes or severe storms and their impacts. Currently, drought research is scattered across many agencies, without formal coordination or planning to maximize the value of the research dollars spent or to ensure that the highest priority needs of the public and decision-makers are being addressed. Improved coordination of drought research within and between levels of government, as well as with private entities and universities would help to accelerate the development and provision of scientifically-based information and products to better prepare for, manage, and respond to the impacts of drought. To be most effective, drought research should include sustained interactions between decision-makers and the research community to ensure that this research focuses on the highest priority needs for drought information.

Significant research efforts should focus on the development of improved drought monitoring and forecasts at the regional to local spatial resolutions where decisions are made. Research is needed to better understand decision processes and opportunities for the uses of drought information in applications. Improvements in the prediction of drought frequency, duration, and severity will provide stakeholders with the decision support tools needed for proactive planning to minimize drought impacts. Revised drought indices should be developed to better meet the needs of decision-makers while drawing on advances in scientific understanding. At the same time, the limitations of drought tools and products must be characterized so that users understand the inherent uncertainties they contain. Research should also investigate the value of coupling physically based drought models to impact or adaptive management models. Better documentation of past droughts, including the relationships between the extent, severity,

and longevity, and impacts, can help improve estimates of possible future impacts and develop plausible "If. then …" scenarios to assist decision-making. Finally, research into the possible future role and impacts of weather modification needs to be included so that a clear understanding of its future utility is available.

INFORMATION DISSEMINATION AND FEEDBACK

Drought Information Dissemination

Drought monitoring and prediction information produced by federal and nonfederal partners currently creates a problem for many users. The information is often complex and, for the most part, is not presented in a standardized format. NIDIS will provide drought information through an Internet gateway in an interactive environment. The gateway will also provide access to research that is not always disseminated in a timely fashion or through easily accessible modes.

User Feedback

NIDIS is intended to have active user interaction in identifying, formulating and resolving problems with the use of scientific information. Documentation and outreach is essential in informing the user community while also building confidence in the system's integrity. User feedback on system functionality and ease of use is an adaptive management approach essential to system maintenance and improvement.

The trust of users is an essential ingredient that must be maintained for the proposed system to have credibility and long-term support. This requires a continual focus on education, outreach, product development, verification, and refinement. To gather user input, panels for initial testing of the system should be created to include users from different education levels, sectors of the economy, and federal, state and local government entities.

RECOMMENDATIONS

The recommendations outlined in this report will require the commitment of needed personnel, funding and cooperation in order to be successfully accomplished.

1) Establishing NIDIS: The successful creation of the National Integrated Drought Information System (NIDIS) will require leadership to oversee the development, coordination, and implementation of its various components and programs. Congressional action, the realignment of agency priorities, and the development of new partnerships will need to take place for NIDIS to become a reality.

> **Recommendation 1a:** Congress should authorize and fund NIDIS through legislation such as the *National Drought Preparedness Act of 2003*. NIDIS will provide integrated information and decision support tools to help water users and resource managers prepare and implement proactive strategies to mitigate the impacts of drought.
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> **Recommendation 1b:** The National Oceanic and Atmospheric Administration (NOAA) should be the lead federal agency in organizing and coordinating NIDIS.

Recommendation 1c: In anticipation of Congressional action authorizing NIDIS, NOAA should immediately establish a broad-based Implementation Team to begin implementation of those aspects of NIDIS that can be accomplished with existing authorities and resources.

Recommendation 1d: States and regional groups should have a designated, and permanently funded, drought focal point (e.g. State Drought Advisory Council, State Climatologist, Drought Task Force, Drought Coordinator, etc.). The focal points will receive, develop and use drought-related information, and serve as a conduit between water users and resource managers, and state, regional, and federal officials.

2) Data Needs and Integration Tools: Water users and resource managers need credible and readily accessible drought information which describes current and forecasted drought conditions and impacts in order to make informed management decisions.

Recommendation 2a: The NIDIS framework must include environmental data collection networks. Networks should be stable, modernized and expanded in order to provide the hydroclimatic data needed to assess drought risk. These data need to be real-time, have adequate spatial distribution, long-term continuity, and quality assurance to meet NIDIS requirements.

1. NOAA's multi-use National Mesonet, made up of a modernized Cooperative Observer Network at its core, should be created and integrated with other federal and non-federal networks.
2. Additional federal and non-federal networks are also vital to the success of NIDIS (such as those operated by USGS, USDA/NRCS, USDA/Forest Service, DOI's Bureau of Land Management, Bureau of Reclamation, etc...), and resources need to be devoted to these networks in order to maintain and strengthen their critical monitoring capabilities.

Recommendation 2b: Once data is compiled, the NIDIS framework should convert and integrate the data into useful information. The NIDIS Leadership Team should identify and evaluate current and historical climate, water supply, and drought indices for their utility and applicability. NIDIS needs to be built on the integration of these existing databases, and expanded to fill information gaps. Tools and programs to fill current gaps in drought monitoring may include the following:

1. Integrating meteorological, climatological, hydrological, and agricultural/vegetation drought assessment tools within the NIDIS infrastructure.
2. Developing new drought assessment tools that provide access to environmental data and analyses at the appropriate level (e.g. county) in a GIS modeling framework.

3. Creating new water resources assessment tools to improve the understanding of hydrological drought.
4. Producing tools that generate short- and long-term drought forecasts specific to user needs and locations.
5. Assembling tools to assimilate both remotely sensed (e.g. satellite, radar) and in situ instrument-based observations, with emphasis on techniques to analyze and model drought status that integrates both types of observations.

Recommendation 2c: NIDIS needs to provide a methodology for accurately and more comprehensively quantifying the reporting of drought losses across all necessary sectors and scales, through the following actions:

1. Developing a web-based reporting system to collect quantitative and qualitative drought impacts information for all sectors into a national database within an interactive GIS modeling framework.
2. Developing and implementing tools capable of integrating drought impacts and environmental data for purposes of impact mitigation and adaptive management.
3. The NIDIS Implementation Team should identify opportunities in current agency programs to collect relevant drought impacts information. For example, USDA's National Agricultural Statistical Survey (NASS) questionnaire could be modified to include information on crops, acreages, and estimated values affected by drought. NASS could also be used to establish a progress report for other drought issues, i.e. economic and social, as needed.

3) Research Needs. Water users and resource managers must make risk management decisions and investments based on current and anticipated climatic conditions. They need more accurate monitoring and more reliable forecasting of drought conditions to make these decisions. Applied research is needed to improve forecasting of short- and long-term drought conditions that can be used to make knowledgeable and timely decisions.

Recommendation 3a: Improve the coordination and program delivery across interagency, intergovernmental, and private sector science and research programs by:

1. Improving capabilities to monitor, understand, and forecast droughts.
2. Developing methodologies to integrate climate, hydrologic, socioeconomic and ecosystem inputs to better understand and quantify the linkages between the physical characteristics of drought, the impacts that result from droughts, and the triggers used by decision makers, such as local drought responses or federal drought programs.
3. Identifying regional differences in drought impacts and related information needs and delivery systems, and develop regionally specific drought monitoring and forecasts.

4. Developing new decision support tools, such as drought "scenarios" (e.g., "If …then"), that would enable decision-makers to better consider ranges of risks and options.
5. Improving the scientific basis for understanding groundwater and surface water relationships and develop triggers and thresholds for critical surface water flows and groundwater levels.
6. Improving the understanding and future possible roles for weather modification in drought mitigation.
7. Better focusing the current research program at USDA's Agricultural Research Service (ARS) by encouraging them to dedicate at least five percent of their research budget to drought issues. This can be accomplished through a panel of interagency scientists to help USDA select the research proposals.

4) Facilitating Drought Preparedness Programs. NIDIS will provide a sound, scientific basis to develop effective drought mitigation and response plans, by describing the nature and magnitude of the historical drought threat and providing information on the likelihood and severity of drought. Well crafted plans should include "triggers" that identify when actions identified in these plans should occur. Additionally, federal drought programs need better coordinated "triggers" to facilitate timely assistance to areas where drought is emerging or prevalent.

Recommendation 4a: NIDIS should support drought planning by providing credible information to facilitate and validate the use of scientific-based triggers in preparedness plans that will result in actions to minimize impacts and reduce risks.

Recommendation 4b: The NIDIS Implementation Team should conduct an analysis and make recommendations concerning federal drought assistance programs regarding how and when assistance is provided under each program. More appropriate and timely drought-based triggers and thresholds are needed in order to improve the process for qualifying for federal drought relief programs and drought emergency declarations.

5) Interaction and Education. NIDIS must provide a framework for interaction and education of all water users, natural resource managers and the public.

Recommendation 5a: In order to assure feedback from the various users of NIDIS, address their information needs, and improve the design of the NIDIS, NOAA and the NIDIS Implementation Team should perform ongoing evaluation of the usefulness, usability, and timeliness of NIDIS products.

Recommendation 5b: NIDIS should provide guidance and assistance for education programs and outreach training on ways to plan for, mitigate, anticipate and respond to droughts.