FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

FINAL REPORT

STATEWIDE HYDROLOGIC DATA COLLECTION/DISSEMINATION NETWORK

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Registered Professional Engineer (Civil)
CERTIFICATE NO. 17928
GEORGE V. SABOL
Date Signed 26 April 95
ARIZONA, U.S.A.

Registered Professional Engineer (Civil)
CERTIFICATE NO. 14720
PATRICIA QUINN DESCHAMPS
Date Signed 4/26/95
ARIZONA, U.S.A.

by

George V. Sabol Consulting Engineers, Inc.
Scottsdale, Arizona

in association with

Henz Meteorological Services
and
Jon Behrens & Associates, Inc.

APRIL 1995

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LIST OF ACRONYMS

Arizona ALERT Users Group	AAUG
Arizona Department of Water Resources	ADWR
Arizona Department of Transportation	ADOT
Arizona Division of Emergency Management	ADEM
Arizona Floodplain Management Association	AFMA
Automated Field Operation System	AFOS
Automated Local Evaluation in Real Time	ALERT
Central Arizona Water Conservation District	CAWCD
Colorado Basin River Forecast Center	CBRFC
Early Warning System	EWS
Emergency Operations Center	EOC
Federal Emergency Management Agency	FEMA
Flood Control District of Maricopa County	FCDMC
Flood Warning System	FWS
Geographic Information System	GIS
Geostationary Environmental Orbiting Satellite	GOES
National Oceanic and Atmospheric Administration	NOAA
National Severe Storms Laboratory	NSSL
National Weather Service	NWS
NEXRAD Weather Service Forecast Office	NWSFO
Next Generation Weather Radar	NEXRAD
Phoenix Real-Time Instrumentation for Surface Meteorological Studies	PRISMS
Pima County Flood Control District	PCFCD
Quantitative Precipitation Forecast	QPF
Salt River Project	SRP
U.S. Agricultural Research Service	ARS
U.S. Army Corps of Engineers	COE
U.S. Bureau of Indian Affairs	BIA
U.S. Bureau of Reclamation	USBR
U.S. Federal Highway Administration	FHWA
U.S. Geological Survey	USGS
U.S. Soil Conservation Service	SCS

EXECUTIVE SUMMARY

The flooding in Arizona during January and February 1993 was a reminder of the serious flood hazard that exists throughout Arizona. Those floods also were a vivid indicator of the deficiencies in flood warning in Arizona and the serious consequences of those deficiencies. Two major problems were encountered during those floods, and these are probably typical of all significant flooding in Arizona. First, real-time data is needed so that emergency response agencies and those affected citizens can better manage the flood response actions. Second, better communication is needed between the numerous agency personnel so that the appropriate emergency response decisions - often life-saving decisions - can be made.

These points underscore the importance of having an organized flood warning plan. Lessons learned from the 1993 flood experience have impacted current operations and have led to some improvement in the flood warning capability by better utilizing existing flood detection networks in conjunction with the development of localized flood warning plans. Critical decision making will be significantly streamlined by the existence of a strong, effective statewide flood warning plan and the implementation of the Statewide Hydrologic Data Collection/Dissemination Network (referred to as the Statewide Network).

The Statewide Network is to be, among other things, a system to collect hydrometeorologic data and information, process that data and information, and to disseminate it among various users within the State of Arizona. The primary purpose of the Statewide Network is to improve the effectiveness of flood response actions and information exchanges that are needed during floods in Arizona.

To facilitate the design of a truly effective system, potential users of the Statewide Network were assessed as to their responsibilities, resources, capabilities, and perceived needs relative to flood warning. Concurrently, input from selected flood warning system operators in other states was solicited. Summaries of these interviews are included in the appendices. The key result of extensive communication with numerous agencies and

individuals in Arizona is that there are two tiers of users of flood warning system information in Arizona. These two user groups are defined as:

Tier 1 - Those with full-time staffs dedicated to hydrometeorology and water management.

Tier 2 - Those whose primary function is broadly defined and for whom flood response is considered on an as-needed basis.

Satisfying the needs of these two user groups will have a major impact on the character of the information flow over the network. Similarly, the synthesis of the successful commonalities of the out-of-state systems provides key concepts which are embodied into the concept design of the Statewide Network. The major findings resulting from the interview of both potential users of the network and operators of out-of-state systems are discussed in detail in the report.

The purpose of this project is to develop the concept design of the Statewide Network. An iterative process was employed in the development of the concept design by testing and refining the design through interaction with users, both individually and collectively. Characteristic of the iterative process are several intermediate products that were used to clarify logic and for communication with users. From these intermediate products, a concept design evolved of a computational and communications network. The concept design section of this report presents recommendations for computers and communications. Qualitative recommendations about databases and information displays are also included. Finally, cost estimates for the construction, operation, and maintenance of the Statewide Network are presented for planning purposes.

The hardware and software that comprise the conceptual design combined with the existing hydrologic data collection systems are both adequate and complete to serve as the backbone of a statewide flood warning system. Should Arizona decide to proceed to final design, the hardware and software infrastructure of a flood warning system, as described herein, would be complete. However, hardware and software are not all that is needed to have a fully functional flood warning system. There is considerable human organization and response planning that are required if Arizona is to turn a state-of-the-practice communication and instrumentation system into a flood warning system. An effective,

operational flood warning system should consist of eight components: planning, training, prediction, detection, communication, maintenance, emergency response, and planned response. Ultimately, the Statewide Network is essential to an overall Arizona flood warning system.

Because of the multiple uses of hydrometeorologic data and related information and because of the tremendous capabilities that are afforded by the Statewide Network in regard to the collection, compilation, manipulation, storage, and dissemination capabilities, it is envisioned that the Statewide Network also will have many alternative uses for a wide range of users in Arizona. The benefits afforded by the cultivation of alternative uses for the Arizona flood warning system include sustaining user familiarity with the operation of the system during times of no flooding, and generating sufficient cash flow for the system to be self-sustaining and potentially an economic asset to Arizona. Therefore, many of the potential alternative uses are presented and the benefits of those uses qualitatively evaluated.

The implementation of the concept design of the Statewide Network is the logical initial step in the development of the Arizona flood warning system. The recommended plan for implementation of the Statewide Network involves several key elements, all of which should be undertaken. First, a lead agency needs to be designated for further work on the Statewide Network. The Arizona Department of Water Resources is the logical lead agency due to recent legislative mandates and its role as the local sponsor for the U.S. Army Corps of Engineers Arizona Flood Control Study project. The lead agency, in cooperation with the Network Committee, should formulate a plan of action, enter into agreements to execute the plan of action, and establish the administrative branch of the Arizona flood warning system. Second, funding opportunities must be pursued and finalized. This should include the Corps of Engineers through its Arizona Flood Control Study project, the Arizona legislature, oil-overcharge funds, and opportunities through alternative uses. Third, the final design of the Statewide Network should be initiated. It is unlikely that this design can be undertaken by the Network Committee itself or by any of the Network Committee members. It will probably need to be performed by contract.

Concurrent with the implementation of the Statewide Network, efforts should progress to bring about the Arizona flood warning system and to stimulate alternative uses.

For the flood warning system, strategically placed ALERT networks are needed throughout the state, some of which are provided for in the COE Arizona Flood Control Study. A broad spectrum of planning is needed along with carefully designed training. The prediction component of the flood warning system will need to be enhanced, and the response component will need to be strengthened. An organized and concerted effort must be made to attract alternative uses which is vital to sustain funding of the system and to foster on-going training. Education and research grants can be a viable source of funding through alternative uses. A newsletter can be used to showcase the system, to solicit alternative uses throughout Arizona, and to garner political and financial support.

The implementation of the concept design of the Statewide Network is the initial step in the development of the Arizona flood warning system and potentially a multi-use environmental network. The implementation plan includes a framework for this process from the current status of flood warning in Arizona toward the goals of an effective, self-sustaining flood warning system augmented by an environmental mesonet with many alternative uses. Clearly, this process will require focused vision and leadership from the Network Committee members and other state organizations if the goals are to achieve fruition.

INTRODUCTION

Project Purpose

The Statewide Hydrologic Data Collection/Dissemination Network (referred to as the Statewide Network) is to be, among other things, a system to collect hydrometeorologic data and information, process that data and information, and to disseminate it among various users within the State of Arizona. The primary purpose of the Statewide Network is to improve the effectiveness of flood response actions and information exchange that are needed during floods in Arizona. Ultimately, the Statewide Network is to be a vital component of an overall Arizona flood warning system. Because of the multiple uses of hydrometeorologic data and related information and because of the tremendous capabilities that are afforded by the Statewide Network in regard to the collection, compilation, manipulation, storage, and dissemination capabilities, it is envisioned that the Statewide Network also will have many alternative uses for a multiple of users in Arizona.

The purpose of this project is to develop the concept design of the Statewide Network. Since the Statewide Network is to serve as a vital component of an Arizona flood warning system, the needs of the network in regard to flood warning are assessed and defined. It is also realized that the alternative uses of the Statewide Network will have a wide range of uses other than for flood warning and response. Therefore, many of the potential alternative uses are presented and the benefits of those uses qualitatively evaluated.

This report presents a brief background in regard to the Statewide Network and flood warning in Arizona. The concept design of the Statewide Network and the method of defining that concept design are presented along with an implementation plan. Alternative uses are discussed in a separate section. The key conclusions and recommendations of this study are provided to guide decision makers in Arizona in advancing to a fully functional and effective Arizona flood warning system.

This project was performed for the Flood Control District of Maricopa County under Contract No. 94-19. The Flood Control District agreed to undertake this Statewide Network scoping study as a contribution to the Network Committee's goals of achieving a flood warning system for Arizona.

Project Background

General

Prior to the flooding during the late 1970s and early 1980s, there was little automated monitoring of streamflow or precipitation from remote locations in Arizona. After the 1980 floods, the Arizona Department of Water Resources (ADWR), the Flood Control District of Maricopa County (FCDMC), the Pima County Flood Control District (PCFCD), and the Salt River Project (SRP) expanded and improved its gaging networks to provide more real-time data from the streams and watersheds for which these agencies have responsibility. Data from these, and networks operated by other agencies, were independently collected and archived by the agency that operated the network via a variety of electronic means including radio, telephone, and satellite telemetry. In some cases, cooperative agreements exist between agencies allowing for cost-sharing and/or the transmittal of data as, for example, between ADWR and the National Weather Service (NWS). Refer to Appendix A for a complete inventory, complied by ADWR, of all hydrometeorological data collection stations within Arizona at this time (February 1995).

1993 Floods

The flooding in Arizona during January and February 1993 was a reminder of the serious flood hazard that exists throughout Arizona. The severity and magnitude of the 1993 Arizona floods were unprecedented in recent history. Record precipitation and streamflow were observed across Arizona with major damage recorded in virtually every county. Every major reservoir in the state filled to capacity and released record volumes of water downstream. Those floods were a vivid indicator of the deficiencies in flood warning in Arizona and the serious consequences of those deficiencies. As a result, the U.S. Army Corps of Engineers (COE) was directed by Congress to study statewide flood warning.

The Governor's Gila River Task Force, created during the statewide flooding in 1993, reviewed the many flood-related problems and recommended assembling the various water management and disaster response agencies within the state. The goals of this assembly were to discuss past floods, future operations and constraints, and to improve communication among its members. This assembly organized in November 1993 as the Governor's Flood Symposium. Experience gained during the 1993 floods in Arizona clearly identified two areas for improvements:

1. More real-time data and information are needed by the action agencies that must deal with flooding problems, as well as by those who are directly affected by floods.

2. Water management and action agency personnel require better communication and faster access to real-time data to streamline their critical life-saving decisions.

Current Operations

The National Weather Service (NWS) issues weather and river forecasts and warnings to water managers, action agencies and to the public. SRP, the U.S. Army Corps of Engineers (COE), the U.S. Bureau of Reclamation (USBR), and the Bureau of Indian Affairs (BIA) are each responsible for managing reservoirs and operating major dams in Arizona. The Arizona Division of Emergency Management (ADEM) is, at a statewide level, responsible for public safety and coordinating the response to a flood event. Other local entities, such as county flood control districts and municipalities, exercise public safety and flood response activities in cooperation with various state agencies, (ADWR and ADEM), numerous federal agencies (NWS, COE, USBR and BIA), and of the other entities such as SRP. The ADWR collects ALERT hydrometeorological data from counties throughout the state. The decisions made by each of these entities are highly dependent on timely receipt of accurate real-time data and information exchange among all of the entities.

Currently, precipitation, reservoir and streamflow data are collected and archived by many different agencies. The exchange of data and information among the various decision making agencies is an extremely complex and inefficient process. A schematic diagram illustrating the lack of coordination in the existing communications structure is shown in Figure 1.

ALERT Networks

There are several watersheds statewide in Arizona that are continuously monitored by automated flood detection systems known as ALERT (Automated Local Evaluation in Real Time). The ALERT system was developed by the NWS's California-Nevada River Forecast Center in Sacramento, California. The system consists of event-reporting precipitation and river gages with automated data collection and processing managed by powerful microcomputers. The precipitation gages are modular, self-contained event reporting units, typically with tipping bucket mechanisms. Each tip of the bucket

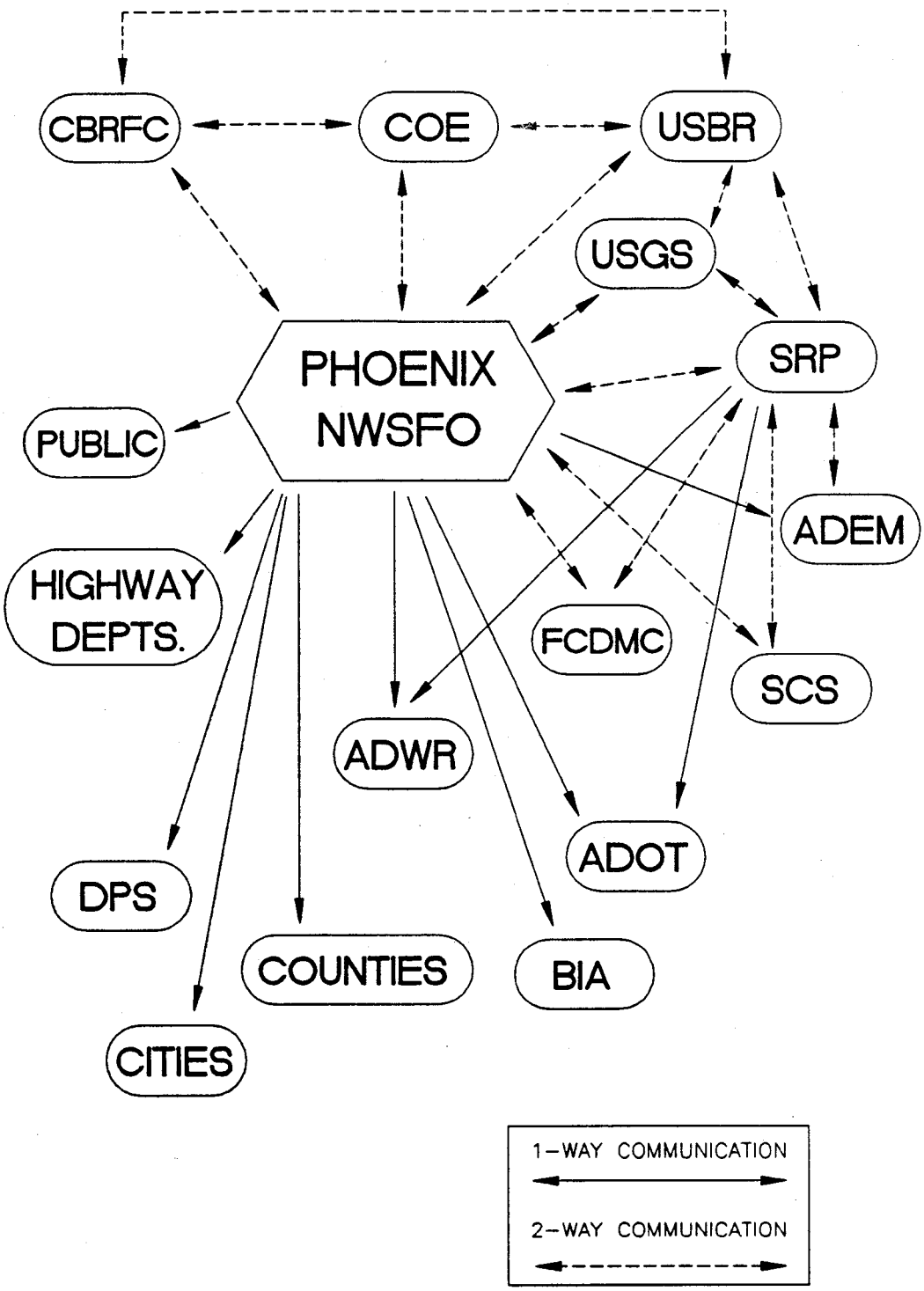


FIGURE 1

Existing Communications Structure (Ref. - Network Committee Position Paper)

generates a radio transmission containing the rain gage location identifier and the accumulated precipitation value. The event reporting river gages transmit incremental changes in river elevation. Data collection and processing hardware consists of a radio receiver to collect event reported radio signals from field stations and a dedicated microcomputer system. The system operates in a fully automatic mode, receiving data and processing information for display to the user.

Several ALERT flood detection systems exist or are in the design stage within Arizona. These systems are primarily localized, basin-specific and are operated on a county-by-county basis. According to legislative mandate, ADWR will assist local entities in the planning, design, and installation of ALERT flood detection systems. The local entities are responsible for the operation and maintenance of its flood warning systems; although, ADWR may provide the required maintenance service, if deemed necessary. ADWR also provides the end users with training on the proper operation of its equipment. ADWR operates an ALERT based system that monitors almost all ALERT sensors within the state. Even during times of no flooding, an automatic monitoring capability contained within the ALERT system alarms the operator of the need for maintenance, such as batteries replacement or semi-annual maintenance checks.

Some smaller systems, such as the Sedona/Oak Creek and Yavapai County systems, are operated for a particular community. The two large metropolitan areas, Phoenix and Tucson, have extensive ALERT systems. ADWR coordinated the implementation of the Sedona/Oak Creek and Yavapai County systems. The COE and ADWR are in the process of implementing ALERT systems in Mohave County, Clifton, and Sulphur Springs Valley north of Willcox. The concept design of the Statewide Network presented in this report proposes that the system functions, among other things, to link the existing ALERT systems to the Statewide Network to facilitate more reliable and timely flood warning.

Corps of Engineers Report

As a result of widespread flooding in Arizona in January 1993, the Congress authorized a study by the COE to identify corrective measures which must be taken to prevent flooding of similar magnitude in the future. The Arizona Flood Control Study Final Report is currently being reviewed internally by the COE and is not available for distribution until such review is completed.

The COE report focuses on the evaluation of nonstructural flood warning alternatives. The COE report proposes the installation of data collection hardware to provide flood threat detection capability coupled with a communication capability within the system for flood warning dissemination. The proposed "backbone" flood warning system is intended to serve as a centralized, comprehensive source of flood warning data and information for federal, state, and county agencies and local emergency response entities.

The COE plan provides for the installation of approximately 120 ALERT precipitation and streamflow gages and 5 regional base stations linked to a central computer system. The COE plan calls for a redundant data and communications system. The central base station will also receive data from other existing gages (USGS, NWS, SCS, SRP, COE), lake levels, snow, lightning, and other ALERT systems. The flood warning capability is planned into the system by establishing preset alarm thresholds which notify end users at the local level that emergency response is required.

It is envisioned that the proposed COE flood warning system will be the backbone of the Statewide Network. The COE requires that its system provides complete, "stand alone "flood detection, communication, and computational capability for flood warning purposes. The system will be designed to accommodate later expansion as the Statewide Network develops. It allows for additional gage networks in other basins and additional communication capability to be incorporated into the system as the Statewide Network is implemented.

The COE stresses the need to ensure the end users are provided timely, accurate information in an easily understood format so that the proper emergency response is enacted. The COE will require that adequate training is provided to users and periodic

coordinated exercises are held. Essential to continued COE support of the proposed system is the development of Emergency Preparedness Plans by local entities.

The COE report has the local support of ADWR. The COE funding support is limited to hardware to provide a basic flood warning system for the state as dictated by the economic benefits. The proposed budget is $1.4M for design and installation of the basic system. ADWR, as the local sponsor, is responsible for the operation and maintenance of the system. The data would be managed under the direction of the Arizona Flood Warning Office within ADWR.

Network Committee

Prior to the Governor's Flood Symposium in November 1993, the COE had been commissioned by Congress to perform a study addressing the implementation of a statewide flood warning system. Representatives from ADWR, FCDMC, SRP, NWS, COE, and ADEM subsequently met to discuss how they could work together to pool resources to achieve the goal of a comprehensive flood data collection/dissemination system (Statewide Network) for Arizona. The consensus of the participants at that meeting was that a comprehensive Statewide Network would greatly facilitate each agency's mission during emergency operations with the net result being an improved ability to save lives and property.

This multi-agency task force evolved into the Network Committee. The Network Committee has expanded to include other entities and is currently comprised of the following agencies:

Arizona Department of Water Resources (ADWR)
Flood Control District of Maricopa County (FCDMC)
National Weather Service (NWS)
U.S. Army Corps of Engineers (COE)
Arizona Division of Emergency Management (ADEM)
Salt River Project (SRP)
U.S. Bureau of Reclamation (USBR)
U.S. Geological Survey (USGS)
Central Arizona Water Conservation District (CAWCD)
State Climatologist for Arizona
Pima County Flood Control District (PCFCD).

Representatives from the Arizona Floodplain Management Association (AFMA) and the Arizona ALERT Users Group (AAUG) often attend regular Network Committee meetings.

The Network Committee's initial focus was to clarify the needs of system users to assure the interests of all potential data sources/users were met when the COE plan was implemented. The Network Committee also provides a forum for dialogue and coordination between its members with respect to data collection hardware, repeater frequencies, maintenance and other issues.

The Network Committee meets on a regular basis to discuss, among other matters, both the preliminary work necessary to design and implement the Statewide Network, and methods for procuring the funding that will be necessary to implement the network. The Committee tentatively agreed to proceed with the implementation of the Statewide Network in the following manner:

1. FCDMC would provide a scoping study to analyze data sources, communication systems, and flood warning needs.

2. ADWR would provide a cost-sharing fund which could be used by local jurisdictions to install and maintain precipitation and stream gages contingent upon funding by the Legislature.

3. SRP would provide a central computer and the personnel to operate and maintain it, so long as incremental costs for meeting requirements over and above SRP duties/functions are covered.

4. ADEM and the COE would investigate sources of federal grants to fund the Statewide Network system.

5. The COE would proceed with the Arizona Flood Control Study to formulate a plan for a statewide flood warning backbone system to collect and disseminate information throughout the state.

This project, the Statewide Hydrologic Data Collection/Dissemination Network scoping study, is the direct result of item 1 above. FCDMC selected George V. Sabol Consulting Engineers, Inc. as the prime consultant with Henz Meteorological Services and Jon Behrens and Associates, Inc. as subconsultants. Those three firms, collectively, are referred to as the project team.

Enabling Legislation

An Arizona Flood Warning Office within ADWR was created in 1979 in conjunction with the National Weather Service (NWS). The office was never expanded to the expected levels of operation because the necessary funding was not provided by the Arizona Legislature.

In 1994, additional manpower and funding needs were recommended by ADWR to the Legislature. Subsequently in April 1994, the Legislature passed and the Governor signed into law ARS 45:1501-1506. This enabling legislation authorizes ADWR to coordinate the development of local flood threat recognition systems and assist communities in the funding, design, installation, operation, and maintenance of those systems. The law also provides staffing support to the Arizona Flood Warning Office. Refer to Appendix B for the complete legislation as enacted.

While the monies in the Flood Warning System Fund are exempt from lapsing, future support by the Legislature is not assured. Concurrently at the federal level, Congressional funding of the COE statewide flood warning system is being reviewed and, once approved, will require fiscal participation by ADWR, the local sponsor. Continued monitoring and collaborative efforts by participating entities are vital to maintaining the support of the Legislature and, hence, the viability of the Statewide Network in Arizona.

Components of a Flood Warning System

This scoping study is focused on the development of a concept design of the Statewide Network to be used for improved statewide response to serious flooding events through improved communication of data and information. The Statewide Network is not to be mistaken for a fully functional flood warning system for Arizona. The Statewide Network, which is the focus of this scoping study, is a vital component of such a statewide flood warning system. However, to perform this scoping study, all of the necessary components of an effective statewide flood warning system must be accounted for in regard to the communication needs of the Statewide Network. The various components of a flood warning system are discussed in the following.

An effective, operational flood warning system should consist of eight components: planning, training, prediction, detection, communication, maintenance, emergency response, and planned response. These components are discussed by Gruntfest (1991) and the National Weather Service (1988) in general terms which have been synthesized into an Arizona specific system for this study. The components are organized into three branches; administration, operations and response. Figure 2 shows the structure of the flood warning system's branches and the components of each. This assumes that the required installation of the necessary infrastructure, such as field detection equipment and communication hardware/software, is completed and the necessary administrative and response components are developed before an effective flood warning capability can be realized.

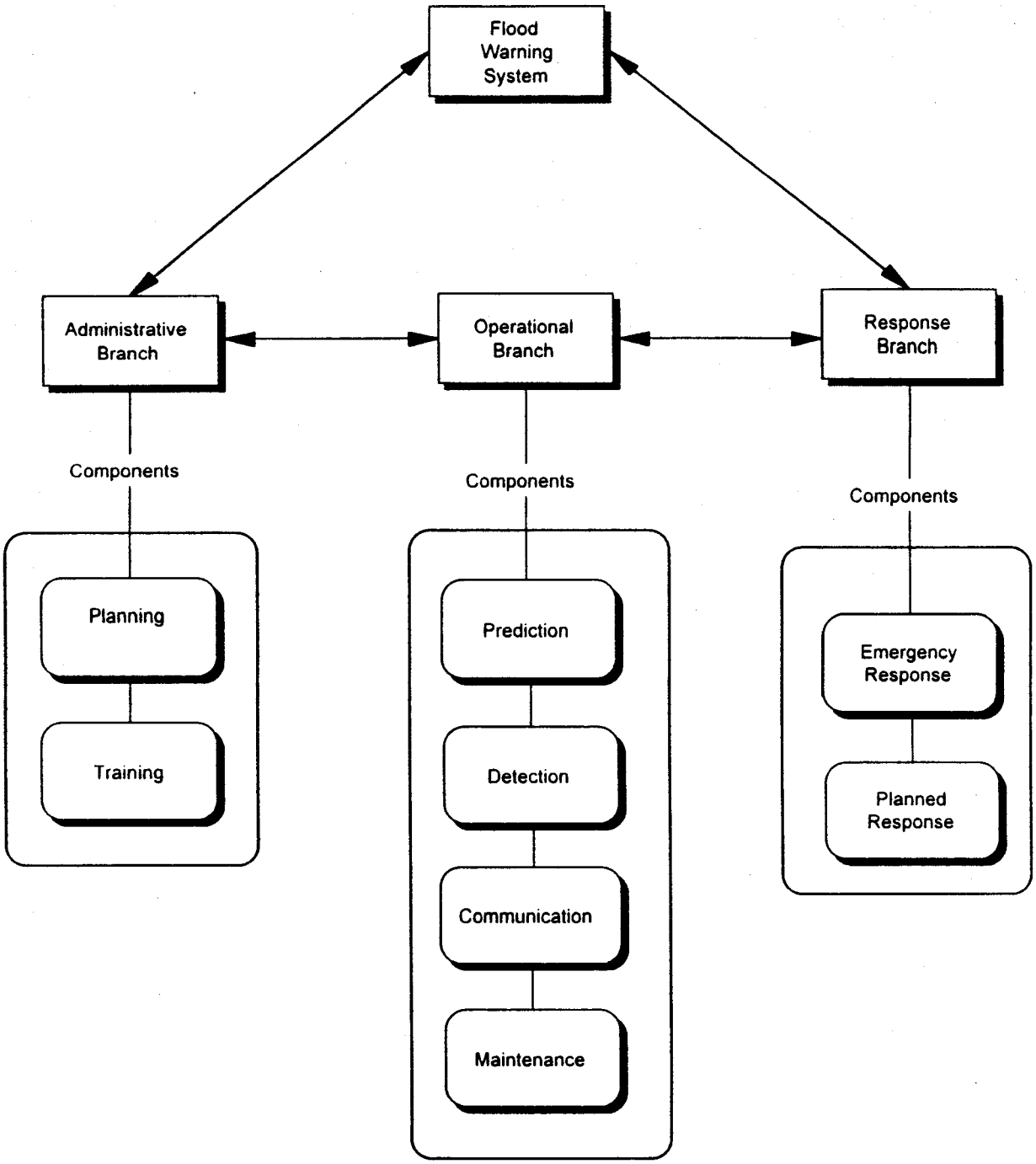


FIGURE 2

Flood Warning System - Branches and Components

The **administrative branch** of the flood warning system is comprised of the planning and training components. The **planning component** must insure that areas of high flood risk have been identified and that a flood warning plan is in place which is specific to the needs of the basin at risk. Additionally the planning component must develop a financial strategy which insures that the system will receive adequate funding to succeed. The **training component** must train personnel to use the hardware/software systems, interpret flood warning products and use them to make decisions within the framework of the flood warning plans. The training component is also responsible for exercising flood warning plans in basins regularly to insure that the plans are responsive to their designed functions.

The **operational branch** of the flood warning system is composed of the prediction, detection, communications, and maintenance components. The **prediction component** insures that the meteorological and hydrological factors producing the flood threat or flood potential are identified pro-actively to insure the activation of the flood warning plan with sufficient, reliable lead-time. The prediction component may embody contributions from the National Weather Service, local participating agencies and private value-added services to meet the specific needs of the flood warning system. The **detection component** provides short-term input to the prediction and then can verify that the predicted location and magnitude of the flood event is occurring. The detection component relies on both regional and local detection networks and equipment. Regional detection networks and equipment maintained by federal agencies, such as WSR-8D Doppler radars, satellites, surface/upper air observation and lightning detection networks, are heavily relied upon by the prediction component to forecast flood threat. Local detection networks such as ALERT basin-specific rain/stream gage networks and automated weather station networks are relied upon to refine and verify short-term forecasts and warnings. The **communication component** insures that the data and information needed to make decisions is available in a timely and reliable manner. In effect this component has the massive organizational task of gathering, formatting, storing and communicating all the data needed by the flood warning system and preparing additional task-related products and information by varying suites of system users in a reliable and accurate manner. This component is the heart of the flood warning system. Additionally, it must insure that the proper hardware, software and communication lines are available for all system users to access needed data and information. This task ranges from the sophisticated computer needs of large users to the

sublime telephone needs of the smallest emergency response agency. Finally the **maintenance component** must insure that the flood warning equipment has been installed to meet the needs of the system and that it is functional when the flood warning system is activated. This function requires regular maintenance visits to remote equipment sites and attention to upgrading equipment as technology and budget allow.

The **response branch** is composed of the emergency response agencies. It must be pro-active to any flooding event. Response must meet the needs of the public during the flooding event according to both the flood warning plan and emergency situations. Clearly the effective mobilization of the response component is dependent upon the successful integration of the other components. In effect, coordinated teamwork between the components is essential for the flood warning system to function in support of the public. Without the interaction of all components, the flood warning system is very likely to fail.

Flood warning systems must consider the potential for failures in regard to its components. Several examples of recent failures in existing systems are noted. This information was gained during the out-of-state interviews that were conducted as part of this scoping study. The implications of these failures are discussed in a latter paragraph of this section.

- The Dallas/Trinity River Levee system was hit by an urban flash flood generated by thunderstorm rainfall on 21 October 1994 during the evening rush hour. Three fatalities and several injuries were noted when the **prediction component** did not forecast the flash flood.

- A 100-year plus rainfall event of 20-30 inches in 72 hours flooded the Houston, Texas, metro area over the 15-17 October 1994 weekend. The unprecedented rainfall washed out a good deal of the **detection network** and taxed the flood warning system to the maximum.

- On 8 October 1994 a late night thunderstorm system produced 6-8 inches of rain in less than 2 hours which resulted in a serious urban flash flood in Austin, Texas. No fatalities or injuries occurred mainly as the result of a dedicated flood emergency manager who was able to overcome **emergency planning** flaws and a **prediction component** failure.

- The Orange County, California flood warning system, was tested by the record mid-January 1995 heavy rainfall of more than 4 inches in less than 24 hours. While the rainfall was **under-predicted**, an **effective flood warning plan** and the **dedicated response** of individuals was able to mitigate the damages from massive mud-slides and urban flooding. The effective public service resulted in no injuries or fatalities due to the flooding.

Table 1 summarizes the performance of the individual flood warning system components during the above mentioned flooding episodes. In each case, the warning system was "swamped" by the magnitude of the event and the failure of individual system components. However, effective communications, emergency action planning, and the dedication of response personnel provided reasonably effective emergency response to the public in most of the flooding events cited.

TABLE 1

Performance of Out-Of-State Flood Warning Systems During Recent Flooding Events

FWS Components (1)	Dallas, TX (2)	Houston, TX (3)	Austin, TX (4)	Orange Cty, CA (5)
Flood Date	21 Oct 1994	15/17 Oct 1994	8 Oct 1994	15-17 Jan 1995
Planning	Fail	Pass	Fail	Pass
Training	None	Pass	Pass	Pass
Maintenance	Pass	Pass	Pass	Pass
Prediction	Fail	Fail	Fail	Fail
Detection	Pass	Pass	Pass	Pass
Communication	Pass	Pass	Fail	Pass
Plan Response	Fail	Pass	Fail	Pass
Emer Response	Pass	Pass	Pass	Pass

These points underscore the importance of having an organized flood warning plan. During the 1993 floods in Arizona, appropriate response actions were taken in spite of some confusion resulting from the lack of a statewide flood warning plan. While some successful emergency response was facilitated by the ad hoc organization of professionals

in key organizations, decision making would have been significantly streamlined by the existence of a statewide flood warning plan. Even if one or more of the components fail to perform up to expectations, the overall flood warning system can still succeed if an effective flood warning plan is in place.

Lessons learned from the 1993 flood experience have impacted current operations and have led to improvement in the flood detection capability by better utilizing existing ALERT networks in conjunction with evolving localized flood warning plans. Since the 1993 floods, experience has shown that it is possible to provide a limited, localized flood warning capability even without a fully operational Arizona flood warning system. The following summarizes the successful performance of selected Arizona flood detection systems during recent flood events.

- The communities of Cornville and Sedona, Arizona on Oak Creek, and Cottonwood and Camp Verde, Arizona on the Verde River were threatened by flooding from those sources on 14-15 February 1995 and again on 5-6 March 1995. The Sedona/Oak Creek and Yavapai County ALERT systems provided sufficient flood and weather-related data to support the decision to evacuate more than 200 flood threatened homes in a timely manner, such that no injuries or loss of life occurred.

- The community of Clifton, Arizona on the San Francisco River experienced significant flood events in late 1994 on 12 November and 6 December and again in early 1995 on 5 January. The ALERT network in the Clifton area provided the necessary data for emergency response officials to determine that the flood peak had passed and no evacuations were necessary. As a result of the timely availability of flood data, the appropriate decision not to evacuate was possible, thereby saving valuable emergency response personnel and financial resources for other, more critical needs.

It is important for the members of the Network Committee and other participating agencies to recognize that the Statewide Network represents the development of a necessary component of a flood warning system rather than the summation of an Arizona flood warning system. Successful flood warning activity in the state will depend on the continuing development and coordination of the other components and a strong, effective flood warning plan.

STUDY PROCEDURE AND FINDINGS

General Approach

The Statewide Network will, by necessity, consist of numerous sources of data and information that are distributed throughout Arizona, and will require dissemination of information and products to multiple users in Arizona. Such a system is a distributed information system. While the possible elements of a distributed information system are known, neither the project team nor the user community were certain at the start of this project which of those elements might be useful in Arizona. Accordingly, it was decided to use an iterative approach wherein a network "model" was formulated and tested with real users. Appropriate modifications led to refinements of the model. The knowledge gained from that process was further analyzed and subsequently synthesized into a matrix to determine the life-cycle of data and products within the network. This matrix was then used in designing the system architecture which overlays the preliminary concept design of the Statewide Network presented in this report.

This scoping study was performed by using a highly interactive procedure. All potential in-state users were contacted and their input and cooperation was solicited. Potential users were selected to achieve a sampling of the many types of users that are anticipated in Arizona, and those potential users were interviewed. All counties and many of the major municipalities were included in this interview process. In addition, selected out-of-state flood warning systems and hydrometeorologic data network operators were contacted and interviewed to gain the benefit of the collective experiences of those agencies. The study procedure and major study findings are presented in the following.

Network User Definition

The project team was able to form tentative model definition very early in the study after coordinating with the FCDMC, ADWR, and SRP, and after visiting the Urban Drainage and Flood Control District in Denver. The key result of extensive communication with numerous agencies and individuals in Arizona is that there are two tiers of users of flood warning system information in Arizona. Those two user groups are defined as follows:

Tier 1 - Those with full-time staffs dedicated to hydrometeorology and water management.

Tier 2 - Those whose primary function is broadly defined and for whom flood response is considered on an as-needed basis.

Satisfying the needs of these two user groups has a major effect on the character of the information flow over the network.

In-State Users

Many of the potential in-state users of the Statewide Network and ultimately of an Arizona flood warning system were selected for interviews. Those interviews determined the users' responsibilities, resources, capabilities, and perceived needs for flood warning. Results of each of those individual interviews are provided in Appendix D. In the following, the major findings of the in-state interviews are summarized in regard to the Statewide Network.

- There are two distinct tiers of user in Arizona. Tier 1 users have full-time staffs working with hydrometeorology and would use the Statewide Network on a daily basis. Tier 2 users do not have such full-time staffs and would use the system much less frequently.

- Tier 1 users have access to a variety of data sources beyond the gage networks in their own basins.

- Tier 2 users are responsible for the collection of much of the basic data that will eventually reside in the databases of the Statewide Network, but these users are typically not staffed or trained to use that raw data directly.

- Tier 1 users are able to digest raw data and make decisions, but they are dependent on Tier 2 users to supply much of that data.

- The nature of flooding in Arizona is periodic. Therefore, it may be difficult to maintain a broad focus over the multi-year horizon that is needed to bring the Statewide Network into existence.

- There is no single organization within Arizona with the funding, staff and expertise that are necessary to build and operate the Statewide Network. Staff and expertise exist within the Network Committee organizations, as a whole, but no one organization appears to possess all of the necessary elements at this time.

- The Arizona Legislature on 16 March 1995 appropriated funds to support the ADWR Arizona Flood Warning Office and the Flood Warning System Fund for the next two years and appears committed to continuing that support. In combination with the resources available through the COE Arizona Flood Control Study and potentially through other agency members of the Network Committee, it appears that the momentum is gaining in the cooperative effort to implement the Statewide Network.

Out-Of-State Flood Warning Systems

The out-of-state flood warning systems that were interviewed during this study provided quite a diversified group with most systems directly supporting population centers of over 500,000 to 2,000,000 people. Summaries of each of those agencies' interviews are provided in Appendix C. The Oklahoma Climatological Survey's (OCS) Mesonet, and the Pennsylvania Emergency Management Agency (PEMA) Flood Warning Network are exceptions in that both systems support entire states and provide information to both major population centers and to rural areas. Despite the diversity of the several out-of-state systems, certain common themes and attributes are associated in a repeated manner with the most successful systems. The out-of-state systems' operational attributes and performance characteristics are related to Tier 1 and Tier 2 Arizona organizations. In general, the Tier 1 organizations either maintain an observation network of over 100 sites or have responsibilities to organizations over an entire state. The three Tier 1 type out-of-state systems are the OCS Mesonet, the PEMA Flood Warning Network and the Urban Drainage & Flood Control District's (UDFCD) Flash Flood Prediction Program. The other five out-of-state systems that were visited are more similar to Arizona Tier 2 type organizations and generally support either a county or city area.

The common attributes and performance characteristics of the out-of-state systems are summarized in Table 2. They include the number of sensor sites in the system; the number of central processing units to ingest, format and disseminate products; the issuance of internal warnings; the cost of the system installation and equipment; annual operations and maintenance budgets; the number of full-time equivalent employees; the number of users served; and, the liability issues affecting the program.

TABLE 2

Common Attributes and Characteristics of Out-of-State Flood Warning Systems

	# Sites (1)	CPU (2)	Wrngs (3)	Cost (4)	O&M (5)	FTE's (6)	Users (7)	Liability (8)
Tier 1								
OCS	111	2 sites	NO	$3.3M*	$ 0.8M	5-8	450+	None
PEMA	231	1 site	YES	**	$ 1.5M	14	67	None
UDFCD ****	136	2 sites	YES	$1.1M	$200K	1***	57+	None
Tier 2								
DALLAS	48	2 sites	NO/yes	$0.45M	$220K	6	7	None
HOUSTON	76	2 sites	NO/yes	$0.55M	$250K	5	15+	None
AUSTIN	85	2 sites	NO/yes	$0.75M	$50K	5	12	None
TULSA	54	2 sites	NO/yes	$0.5M	$18K	2	16	None
COLO SPG	58	5 sites	NO/yes	$0.5M	$19K	0.75	10	None

* $1.1M for equipment, $2.2M for design, install and develop over 2 years
** NWS purchased IFLOWS sites, state spent approximately $1.7M for equipment
*** UDFCD contracts to Henz Meteorological Services for weather support (~ 1FTE, $50K) and Diad, Inc. for maintenance (~1 FTE, $60K)
**** UDFCD Flash Flood Prediction Program operates 6-8 months per year

In Table 2, the column listed as "Wrngs" refers to the internal policy of the operating agency to issue either NWS flash flood or flood warnings or a combination of NWS and internal flood warnings to its users. The upper case NO refers to the agency's exclusive use of NWS warnings while the upper case YES refers the use of a combination of NWS and internal warnings. The lower case yes after a NO is shown when an agency occasionally breaks internal policy and issues "unofficial" flash flood warnings to its users when NWS warnings are needed but have not been issued. It is noted that the OCS Mesonet is not a flood warning system, per se, however the mesonet does provide data to the NWS which uses that data in its flood warning activities. Clearly, all operating agencies of true flood warning systems issue warnings, be they official or "unofficial," when the situation warrants. The Statewide Network should consider this point and evaluate it more fully as an operational posture for the program is decided.

The synthesis of the out-of-state systems' successful commonalties provide key concepts which should be embodied into the concept design of the Statewide Network. The commonalties which apply to the Statewide Network are summarized in the key statements listed below:

- The network should develop close ties to users and should be responsive to meeting their needs. The system should be **interactive** with the user and allow **send/receive** capabilities of the data and associated products.

- A state directed or legislated mandate, funding law or taxing mechanism is needed to provide **sustaining funds** for the flood warning system. Another option is for the program to become **self-sustaining** through the development of **alternative uses** which generate fiscal support. Strong alternative uses could be realized that would create funds through research grants, savings in water and energy conservation, and numerous other applications.

- A **state agency** (ADWR), should **manage** the central processing unit ingest/dissemination of the system database and its products to assist in maintaining fiscal control, security, accessibility and affordability of the network database.

- A **redundant central processing unit** is strongly favored to provide for database preservation during periods of severe weather or computer failure.

- A strong, **cooperative effort with the National Weather Service** is vital. However, dependency on National Weather Service prediction products should be tempered with **value-added services**, especially quantitative precipitation forecasts.

- The planning and development of a Statewide Network and a flood warning system should be used to **develop and maintain a strong political and operational base of interest in the system among both the users and alternative use communities.** E-mail and a system newsletter are possible initial applications which could foster sponsorship.

These common traits of the interviewed out-of-state systems are used to guide the concept design of the Statewide Network and to act as a framework for its development. Each of the points can stand alone as a significant contribution to guiding the design of the network. The OCS Mesonet's example of locating the redundant central processing units at state universities is worthy of consideration in Arizona. However, universities would be expected to provide operational and fiscal support that would be garnered through research

grants and alternative uses. The use of a newsletter which detailed the development and needs of the network while showcasing its potential was instrumental in the development of a strong user/sponsorship base for the OCS Mesonet.

Procedure for Concept Design

The procedural steps that were used in the evolution of the concept design of the Statewide Network is described in general terms in this section. The details of the recommended Statewide Network concept design is presented in the next chapter of this report.

Model Formulation

The combined experience of the project team provided a foundation of professional knowledge upon which to begin formulating the network model. A background knowledge of the flood-related issues and problems within Arizona together with information gathered from initial interviews with selected users contributed to the formulation of a sound network model that was specific to Arizona.

Additionally, a working knowledge of the Water Resources Decision Support System under development at SRP supplemented the model formulation process in regard to the use of problem-center design techniques to define a range of real operational problems, the identification of data and analytic tools, and the design of a computation/communication network to solve the problems.

Prior knowledge of the operations and functions of the Flash Flood Prediction Program in Denver, Colorado, provided a solid model for cooperation maintained between private entities, local, state, and federal agencies. A site visit by the project team provided insights into training, quantitative precipitation forecasting, hydrometeorology research and development, communications, data networking/dissemination, and warning plan development components while using state-of-the-art technology and concepts.

Information gathered on the operations and structure of out-of-state flood warning systems through site visits and interviews provided valuable feedback used in developing the network model. The concept design benefited significantly from the shared experience

of existing systems by embodying concepts which are applicable to Arizona's needs and avoiding common pitfalls associated with large flood warning systems.

Testing and Refinement

The network model was iteratively tested and refined through a process of interaction with system users both on an individual and on a collective basis. The project team conducted one-on-one interviews with agencies in Arizona to gather input regarding their **responsibilities, resources, capabilities,** and **needs** relative to a flood warning system. This information was checked against the network model. The resulting testing and refinement process strongly influenced the emerging concept design and yielded many improvements that are based on interviews with the system users in Arizona and with the operators of out-of-state flood warning systems.

The final test of the network model and the emerging concept design occurred during the Arizona Floodplain Management Association (AFMA) meeting in November 1994. During that meeting, various product sets that were consistent with the emerging concept design were played against two historical storm events with the people who will eventually use the system. The collective feedback received from both Tier 1 and Tier 2 system user groups verified that the data and product sets that each of the two tiers could optimally use would be necessarily different. The process of network model development, assembly of product sets, and the testing of the model with its product sets resulted in a generalized concept design that was ultimately adopted and is presented herein.

Analysis and Synthesis

Having identified the sources of data within Arizona and having analyzed what products were desirable at various levels within the flood response community, the project team abstracted that knowledge and synthesized it into a Data and Product Matrix contained in Appendix E. The matrix provides a means of tracking the life-cycle of all data within the Statewide Network. The matrix lists all of the organizations that will have access to the Statewide Network in the first column of each page. The column headings contain all of the system's data and products. These are organized progressing from most remote (organizationally) to near term and local. For example, the first column, is for satellite imagery, and the last column is for actual alerts to the public. For each **datum** in the system, the matrix identifies the producer of the datum, the user and purpose of the

datum, verifier of datum accuracy, and long-term repository of the datum. Similarly, for each **product** the matrix identifies where it is produced, what data it depends on, the product users, and where it is to be archived. The Data and Product Matrix is needed for the subsequent network concept design and will be a base document for detailed final design of the Statewide Network and an Arizona flood warning system.

Evolution of Concept Design Development

During the interview and analysis process, the project team began to develop the concept design for the Statewide Network that would satisfy the current need and allow for future growth and expansion. As previously described, concept design was an iterative process; the first steps being tentative with subsequent refinement through further interviews and concept testing. Characteristic of the iterative process are several intermediate products along the way that were briefly used to clarify logic and for communication with the users. For completeness, these products are included in Appendix F even though they are not, strictly speaking, part of the concept design. The concept design evolved through four distinct phases during the project, as briefly described in the following:

Functional and Information Flow Diagram - This diagram identifies all of the functional groupings that are anticipated in the final system and identifies what information they must exchange in order to provide flood warning. This graphical tool was used to communicate the preliminary functional relations of those agencies within Arizona that had been interviewed and to structure further in-state interviews.

Connectivity and Data Flow Diagram - This refinement of the functional and information flow diagram added data sources and data storage as well as indicating what type of communication connection must exist between functional entities in the final system. This refinement was based on information that was gained in out-of-state interviews, and in discussions with members of the Network Committee.

Preliminary Network Concept Design - This further refinement of the first two diagrams added a spatial component by making some tentative choices as to where the nodes of the system might lie within Arizona. The preliminary concept also considered data and communication architecture, services provided, system survivability and economics.

Final Network Concept Design - The final network concept design incorporates the Network Committee's reaction to the prior three diagrams into a concept that all agree can be constructed and which will serve the needs of Arizona. Specific information regarding the concept design is presented in a later section of this report.

Major Study Findings

The major study findings are grouped into four broad areas: organization, products and data, planning and training, and alternative uses.

Organization

For the Statewide Network to be built and for it to succeed, there must be a mechanism established for its funding, staffing and operation. As noted previously, the Network Committee itself, while sufficient to keep the process alive, does not have the structure for either project management or long-term operation. The Committee is ideally suited to establishing policy and direction for the Statewide Network and for the flood warning system that the network will support. If the Committee agrees with this assessment, that still leaves the problem of how to organize to bring the Statewide Network and the Arizona flood warning system into existence.

Three possible routes for system implementation are suggested:

1) An agency could take the lead, assuming both financial and management responsibility for design, construction, operation and maintenance of the entire system. This agency would most likely be ADWR.

2) Each of the members of the Committee could continue its own programs, using the Committee forum to keep the others apprised of its actions. Extensive coordination would be required to achieve a fully functional and efficient system.

3) The Network Committee organizations could form interagency agreements for funding the design and construction of the network and, perhaps, for the operation and maintenance functions. In this scheme, the project would be managed by a lead agency with cost sharing among the members and potentially other alternative users of the system. The work would be performed by the individual organizations and/or by contracting for services.

Products and Data

The products and data that can be used by each of the two tiers of users are radically different. The Tier 1 agencies are interested in large streams of real-time data and are heavily invested in computer graphics and sophisticated computer models. They wish to make nuanced decisions based on the latest data and they have staffs that can fine tune emergency plans during an event. The Tier 2 users only deal with hydrometeorology and flooding on an infrequent basis and would actually find their decisions delayed if they were presented with the data streams and displays used by the Tier 1 agencies. For the Tier 2 agencies, the need is for a standard set of simple products that are sufficiently accurate and self explanatory. In other words, they need information rather than data. These simpler products also require less communication capability than do those used by the Tier 1 agencies.

Planning and Training

The above discussion leads directly to planning and training. The largest problem to be addressed in this area rests with the Tier 2 agencies. The Tier 1 agencies tend to have staffs that are involved with planning for the operation of their structures every day. Thus, while their plans might be subject to improvement, they have the resources to make those improvements and they are able to keep their personnel well trained in the use of their data collection systems. The Tier 2 agencies are a different case, and flood response planning ranges from quite good in such places as Maricopa and Pima Counties to almost nonexistent. Further, the level of planning varies by drainage basin, which is to be expected because floodplain managers naturally concentrate their efforts where the problems are the greatest. The greatest return on the planning and training dollar for the Tier 2 agencies would come from improving emergency response plans.

Alternative Uses

Perhaps the worst thing that could happen would be for Arizona to invest in a Statewide Network and ultimately in a functional flood warning system and then not use it for several years. The upshot could very well be public complacency followed by a disaster wherein the system does not predict/detect a flood or communicate that information in time to save lives and property. To avoid such a grim prospect, the system must be used on a regular basis. Although the enabling legislation (see Appendix B) requires that ALERT flood detection systems that receive state funding be maintained by

local entities or by ADWR, alternative uses are vital to assure that the system will be kept in good repair and that its users will be familiar with how to access its various products and services. In a way, this is another aspect of training. As discussed above, training was concerned with insuring that the users could understand the information that the system was presenting to them. In this case, training has to do with the ability of the users to operate the equipment and find the information that they need. Clearly both aspects are important, and if the system is of wide use outside of floods, the problem of maintaining familiarity with the system will be eased.

While the concept design of the system is based on the need for flood management, there are countless other uses for a system of this power and flexibility. These alternative uses will form the backbone of the system's daily use and are a potential source of continual maintenance and operation funds.

STATEWIDE NETWORK CONCEPT DESIGN

In this section, a concept design of the Statewide Network is presented. As stated earlier in this report, a flood warning system is more than instrumentation, communication and computers. A flood warning system must have all of those things, but it must also have the necessary human infrastructure (planning, training, organization, etc.) and the proper supporting software (models, information displays, databases, etc.). In this section of the report, recommendations for communications and computers are detailed. Qualitative recommendations about databases and information displays are also included. The recommended configuration is **complete** and **adequate** to serve as a component of an Arizona flood warning system. It will be up to those with flood warning responsibility to insure that the other components of a flood warning system are implemented.

System Architecture

System architecture is the term used to describe which of the many possible ways that hardware and software can be combined into a useful system. To be complete, an architectural description must specify how the system will deal with each of the three functions of an information system:

- Data ingestion, storage and access.
- Processing data into information.
- Displaying that information to the user.

For example, an architecture might contemplate a single computer which would collect all data and store it locally, would run local applications against that data and present the user with the results of those applications using a printer. Such an architecture describes the mainframe computer days of the late 1960s and 1970s.

There are several considerations that must be met in specifying the architecture for the Statewide Network. It should be noted that none of these considerations is technical in nature; rather, all are strategic and operational but will in sum strongly influence the technical aspects of the design. The needs of Arizona and those of the system's users are paramount, not those of the computer technicians who will build and operate it. This emphasis is critical to ensure that the final product meets the needs of the users without

being over-designed. The following considerations are proposed in the specification of the system architecture:

Standards

All hardware and software must conform to industry standards. Industry standards for software are designed to accommodate a great diversity of applications, and adherence to such standards insures that adding functionality or changing direction in the future will be possible. Purchasing a complete proprietary solution from a single vendor is not recommended because of future system evolution requirements. A proprietary solution ties the system to the business fortunes of a single company. This inevitably leads to problems later on as the needs for the system change. In summary, the only justification for purchasing a proprietary solution would be a case where the vendor has a system of such commanding technical superiority that performance considerations dominate the decision. That is not the case here as existing standards are fully adequate to do the job.

Extensibility

The architecture chosen should gracefully lend itself to being extended both geographically and functionally. It is not likely that resources will permit the simultaneous purchase of the entire system in a single step. It is more likely that the system will evolve over a number of years starting from a fairly modest, basic installation. The architectural specification should recognize this reality.

Survivability

The system should not be entirely located in a single building or a single river basin. The architecture should accommodate a design that will still function even if one or more computers or communication links should fail or be lost during an emergency.

Logically Centralized

While survivability requires that the system be geographically dispersed, the users should not have to be familiar with the layout in order to get information. Since many of the users will not be expert in the use of distributed information systems, requiring them to learn specialized computer system skills is impractical. If such special skills are not exercised daily, they will not be there when a flood occurs. Since it is doubtful that the casual user of the system will be fully conversant in these skills, it is best not to require

them. This will require additional effort in software development, but is important to the successful utility of the system.

Security

There will be a great many users on the system, many of whom will interconnect their own networks with the Statewide Network. It is to be expected that many of those users will have information that they do not wish to share with the entire network. The system architecture must make provision for keeping selected information private.

Availability

This consideration has two aspects. The first is that critical parts of the system must continuously be on-line. Critical system functions are:

- Real-time data ingestion
- Software concerned with generating alarms
- Real-time data storage and retrieval.

Should any of these functions be unavailable during a flood, the system would not be able to perform its intended function.

The second availability consideration has to do with user access to the system. The access points to the system must be dispersed throughout the state and there must be redundant, secure communication to each access point. For the Statewide Network to succeed, it must be used frequently even if there are no floods for an extended period of time. This requirement can not be met by a single site in Phoenix; even though, with radio repeaters or satellite communications, such a site could directly monitor all of the instruments in the state. In other words, frequency of use and ease of access by users throughout the state would not be best facilitated by only one access site at Phoenix or Tucson, but rather by access sites dispersed statewide.

The architecture which best covers the above considerations is client-server. In the following, the essential aspects of this architecture are discussed and a concept design is developed based on it. The concept design adequately addresses each architectural consideration.

The Client-Server Architecture

A client-server information system divides software into two categories; client software and server software. Client software is invoked by a user to accomplish some task. In performing that task, the software may break it into parts which are subcontracted to other pieces of software. In that sense, the program becomes a client which requests services from other pieces of software. Naturally, the server programs are free to subcontract parts of their tasks to other programs; in which case, they become clients themselves.

In the most generic case, there are three classes of service which must be provided by an information system:

- Data services include the ingestion of data, its storage and provision for access.
- Processing services include all of the functions that are needed to turn data into information.
- Presentation services are all of the software necessary to render information in a form that is usable by system users.

It should be apparent that getting services to cooperate in performing their designated tasks requires that they be able to communicate among themselves. A significant advantage of client-server systems is that this communication can take place over a network rather than being restricted to a single computer. In fact, the architectural considerations of survivability and availability require that the system's services be distributed over multiple computers on a network and that more than one computer be able to provide each service.

Description of Network Services

Data Services

Data services encompass all phases in the life cycle of data and stored information. Data must be brought into the system, it must be stored in a way that allows it to be read in a timely fashion, it must be verified, and it must be removed if it becomes redundant or obsolete. The data services are logically divided among four distinct database servers:

Tactical Decision Support - These database servers contain raw observations from the various gages throughout the state as well as real-time products generated from those and other observations. This is an example of what is known as an on-line transaction processing (OLTP) database. It is optimized for speed of access and updated for the specific purpose of generating products in real-time. It is not well suited for browsing, nor is it well suited to performing floodplain studies and risk analysis. The data is not quality checked and products are routinely superseded rather than being modified. It is vital that the tactical decision support database be continuously on-line and that it be redundant. This will be the primary resource for emergency management.

Strategic Decision Support - This database is used to support floodplain studies, risk analysis, gage siting, research, etc. It is a vital part of the system, but it is not designed for access speed. Rather, it is optimized for browsing and drawing inferences about relationships among the data. All observations and gage readings in this database will be quality checked and so are usable for statistical purposes. It is not vital that the strategic decision support database be either redundant or continuously on-line. It is of greatest use for planning between floods.

Network Configuration - It is anticipated that there will be a number of computers, perhaps running different software, and numerous switches, routers and other communication devices in the Statewide Network. Managing this equipment, its configuration and maintenance will require a dedicated database.

E-mail - One of the major problems during prior floods, often emphasized during the in-state agency interviews, has been poor communication among decision makers. This has been partially solved by ad hoc reports and telephone contacts. Having organizational E-mail accounts and transferring standard products electronically between agencies can greatly improve coordination during a flood.

Processing Services

Processing services change data into information. Processing services fall into three distinct categories:

Alarm Functions - These functions monitor the incoming real-time data stream and make decisions based on preset conditions. They are fundamental to the system and may be as simple as preset thresholds or as complex as expert systems.

Analysis and Product Construction - This covers such things as forecasts, quantitative precipitation forecasts (QPF), floodplain studies, etc. This software makes extensive use of data services to retrieve raw material and of presentation services to present results to the users.

Models - Although models might strictly be considered in the former category, they are different enough to warrant special treatment. Models are both consumers and producers of data within the system. They use either historical or real-time data as boundary conditions and as forcing functions and they produce synthetic data that may be used as the basis for decisions during a flood.

Presentation Services

The final set of services are those dealing with the presentation of information to the users of the system. This presentation service may be divided into two subcategories:

Centrally Produced -These presentations are produced at a central site, perhaps by a third party vendor, and are made available to users on a limited interaction basis. Typical of such products might be satellite imagery, radar products, storm tracks, etc. Generation of such central displays typically requires large amounts of raw data or high performance software. In either case, it is uneconomical either to provide sufficient communication bandwidth or to distribute sufficient computing power to have such displays generated locally.

Locally Produced - These presentations are generated at the point of consumption from basic data. Examples include alarms generated by a base station in response to a streamflow gage or inundation maps produced by a GIS package. The key here is that the software to generate the presentation must be executable from the point of display.

In the strict interpretation of client-server architecture, the location of the presentation software is not of much importance, but as a practical matter software locations are important for two reasons. First is performance; the less network traffic required to produce a display, the more lively and responsive the system will feel to its users. This supports the argument for having frequently used display software distributed throughout the system. The second consideration is economic. Multiple copies of presentation server software cost more than does a single copy and they consume computation power on the local machine where they run. As a result of these considerations there will normally be both local and centralized display servers, the mix being an issue for final design.

Network Concept Design

This section of the report presents a concept design for the Statewide Network. Some tentative choices have been made about the siting of network nodes, the class of communication required and the hardware configuration of node sites. These preliminary choices provide a basis for evaluating the resources that will be required to implement the Statewide Network. This concept design will likely change somewhat during final design and implementation.

The basic design of the Statewide Network contemplates two central sites having substantial computing power, full time staff and high speed communications. These sites are connected to a number of access nodes around the state. The access nodes are further connected to each other, providing a redundant web of communication links.

The design is divided into a number of segments; topology, network protocol, central site configuration, access node configuration, and personnel requirements.

Network Topology

The map in Figure 3 indicates where the tentative node sites might be located throughout Arizona and what communications might exist among them. The lines represent communication links between the nodes. The thick red line between Phoenix and Tucson indicates that these two cities are logical choices for central node sites and that they need

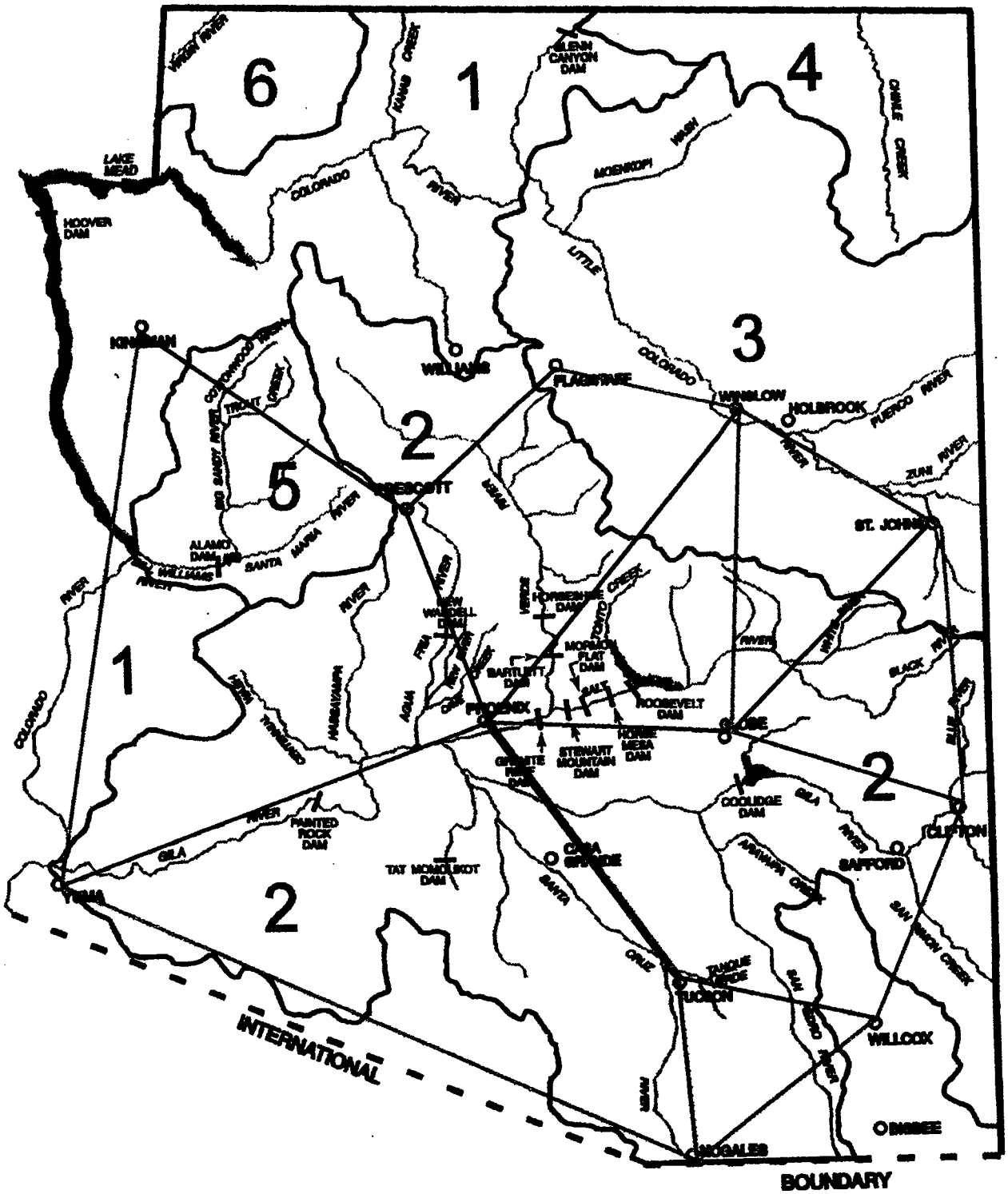


FIGURE 3

Statewide Network Topology

high bandwidth communication to keep their redundant, real-time databases synchronized. For costing purposes, a T1 line is used between these sites. The reason for suggesting these two cities is that they constitute the majority of the population in the state. Further, in Phoenix, SRP and the NWS are collocated in a facility already possessed of considerable computation power. In Tucson, the University of Arizona, the NWS and the USGS will soon be collocated and have the potential for creating the necessary infrastructure.

The other lines in Figure 3 represent lower bandwidth communications. Again, for cost estimating 56KB lines are used, but satellite communications are also an option. While the blue and green lines are of the same capacity, the green lines exist to provide redundant communication paths. One strategy for building the system might be to purchase the blue communication paths as part of a basic system and to fund the green paths through revenues generated by alternate uses. It is not recommended that less than a fully redundant system be implemented, but in the real world of constrained budgets, it may be necessary to build in increments.

This concept does not specify what communications appliance (land line, microwave, satellite, etc.) should be used for the various links; rather, it indicates the capacity required. The choice of appliance will be a final design question. The choice of whether to go with a common carrier (the phone company) or to lease space on a satellite involves more than equipment purchase cost and monthly lease fees (although these are important factors). There may also be personnel differences with cost implications between the choices.

Network Protocol

Since the proposed layout is a web, it is also recommended that the transport protocol take advantage of the high connectivity of a web configuration. This suggests a connectionless protocol which will route packets of information into idle communication paths rather than depending on having an established circuit between communicants. The two industry standard choices are X25 and TCP/IP. While either would serve adequately, TCP/IP is recommended, primarily because it would facilitate INTERNET access for users of the Statewide Network and there are a large number of public domain applications for this protocol.

Central Node Configuration

The two central nodes will be organized around a large workstation server running a multitasking operating system, as illustrated in Figure 4. The database servers will be located at these central nodes, so they will require substantial amounts of on-line storage. The tactical databases must be redundant, so the two central sites will require synchronization software and high bandwidth communications between them. The server software must also provide transparent switching so that the user need not know which site is providing any given service.

The costs associated with each of the central sites will be fairly substantial. Acquisition costs for hardware and software will be in excess of $85,000 per site. If a T1 line is assumed between Phoenix and Tucson, the installation cost will be $3,000 and the lease will be $5,000 per month. Operation and maintenance of the network will require dedicated personnel at the two central sites. For planning purposes, these costs may be prorated at $60,000 per site for direct salary or about $85,000 including benefits and taxes.

The central node configuration diagram also shows a satellite downlink station. It would be possible to purchase earthstation equipment for each node and run the network using leased bandwidth on a commercial satellite. This might be an attractive cost option and merits further study during detailed design.

Access Node Configuration

Access nodes on the statewide topology map (Figure 3) are at all the vertices other than the central sites. The basic piece of equipment at each of these access nodes is a PC workstation, as illustrated in Figure 5. These workstations should use a multitasking operating system that is perhaps more user-friendly than is UNIX (which is a candidate for the central sites). This can vary with the qualifications and interest of the users at each site.

The costs for each of these access node sites will be about $10,000 each for hardware and software. If the network communication is provided by a common carrier, lease costs would be about $300 - $500 per month per line.

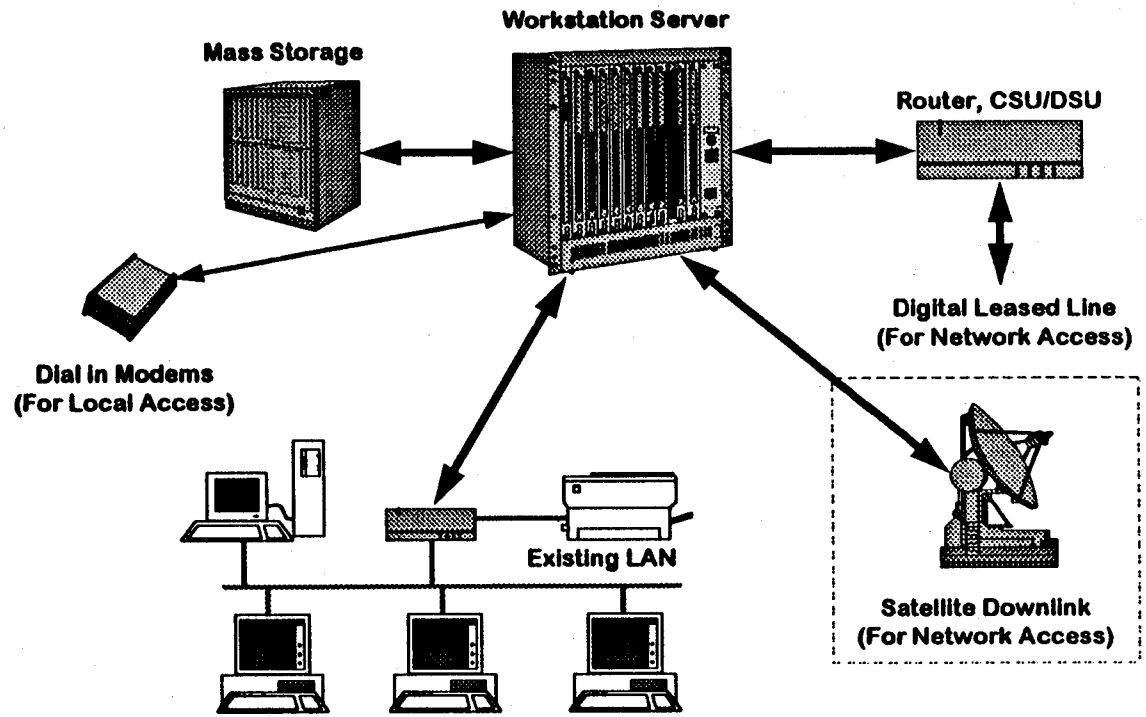


FIGURE 4

Central Node Configuration

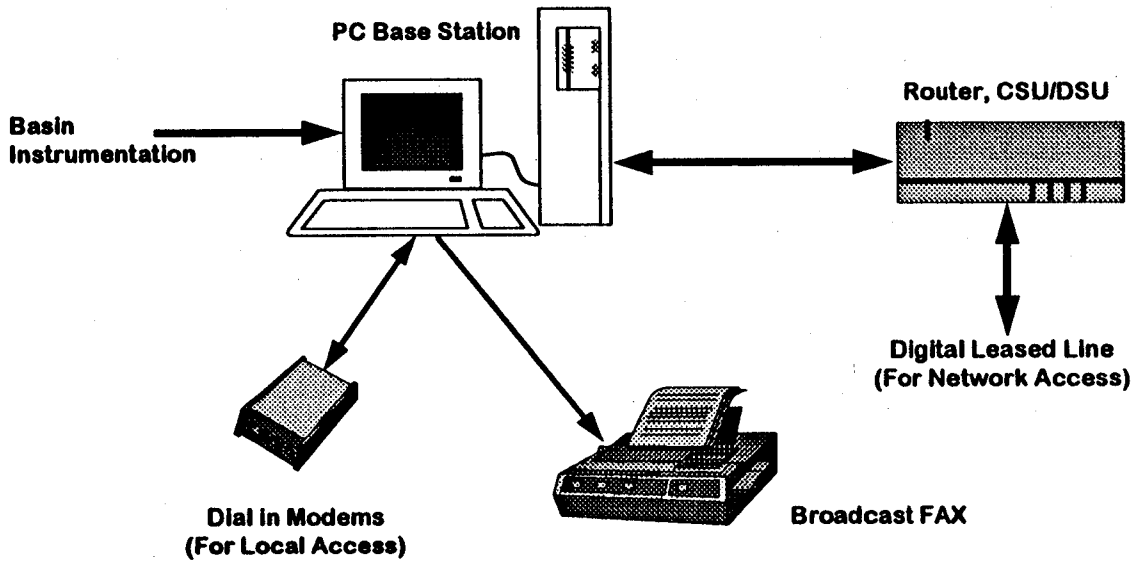


FIGURE 5

Access Node Configuration

Personnel

The operation and maintenance of a system of this complexity will require full-time personnel. Those individuals must have network administration skills as opposed to basin instrumentation skills. It is estimated that the system will require three people; one network administrator at each central site and one supervisory network administrator. For this level of staffing to be effective, the system will need an automated network administration system and configuration database as discussed earlier. It is anticipated that this staff would maintain user authentication information, software version control, and network maintenance for both the central sites and the access nodes.

The supervisor would be paid an estimated $45,000 salary and the site administrators would be paid approximately $38,000. When benefits and taxes are considered, the total personnel costs would be about $170,000 per annum.

Resource Planning Summary

For planning purposes, Table 3 and Table 4 summarize the costs associated with the construction, operation and maintenance of the Statewide Network. These costs will change during final design as choices are made as to the communications appliances (telephone, satellite, etc.) to be used for each link and as to the actual hardware configuration at each site. It is also important to note under equipment costs that much of the hardware already exists in the organizations of the Network Committee members. The amount of potential reduction in acquisition costs will be determined during final design.

TABLE 3

Cost Estimate for Construction of the Statewide Network

Item (1)	Equipment and Software (2)	Communications Installation (3)	Number of Nodes (4)	Total (5)
Central Sites	$85,000	$1,500	2	$173,000
Access Nodes	$10,000	$1,100	10	$111,000
				$284,000

TABLE 4

Cost Estimate for Operation and Maintenance of the Statewide Network

Item (1)	Monthly Lease Expenses (2)	Number of Links (3)	O&M Costs (Blue Links) (4)	O&M Costs (All Links) (5)
Communication Lease Expenses				
T1 Line Monthly Lease	$5,000		$5,000	$5,000
56KB Line Monthly Lease	$400	10 (Blue Links)	$4,000	
		18 (All Links)		$7,200
Per Month Communications Lease			$9,000	$12,200
Annualized O&M Costs				
Annual Communications Lease			$108,000	$146,400
Annual Equipment Replacement			$28,400	$28,400
Personnel (Base salary x 1.4)			$170,000	$170,000
Total Annual O&M Costs			$306,400	$344,800

ALTERNATIVE USES OF THE STATEWIDE NETWORK

Alternative Uses as a Funding Source

The establishment of a sustaining funding mechanism is necessary for the success of the Arizona flood warning system. It is also necessary to insure that the system remains viable and functional after long periods devoid of flooding. A tax based funding mechanism is a possibility, but the establishment of such a tax based fund may be difficult. Another alternative exists in the form of cash flow generation by the Statewide Network database and products. These alternative uses are present in many of the out-of-state flood warning systems that were visited and may have an application in Arizona. In particular, the OCS Mesonet was very successful in generating positive cash flow in Oklahoma. An opportunity for Arizona to develop alternative uses for the Statewide Network is described that is based on the cautious expansion of the Arizona flood warning system into a larger environmental network which serves Arizona in several capacities.

Examples of Out-of- State Alternative Uses

The visits made to out-of-state flood warning systems uncovered a wide variety of alternative uses within each state. The existing alternative uses of flood warning systems found during the out-of-state visits are summarized in Table 5. A review of these alternative uses show the following uses as having the most likely applications in Arizona:

Water Operations and Studies

- Water supply and conservation
- Irrigation management
- Water quality studies and NPDES Permits
- Dam safety
- Water supply forecasting
- Hydraulic design.

Database/Archive

- Forensic and legal applications
- Insurance claims
- Climatological applications
- Research studies
- Building and construction.

Operational Public Needs

- Utility demand prediction
- Recreation
- Air quality forecasts
- Severe weather forecasts
- Fire fighting.

TABLE 5

Alternative Uses of Out-Of-State Flood Warning Systems

ALTERNATIVE	OK (1)	PEMA (2)	UDFCD (3)	DALLAS (4)	HARRIS (5)	AUSTIN (6)	TULSA (7)	C. SPG (8)
Water Supply/Conservation	X		X	X	X	X	X	
Irrigation Management	X		X	X		X		
Water Quality	X	X	X	X	X	X	X	X
Database/Archive	X	X	X	X	X	X	X	
Frost/Freeze Forecast	X	X						
Agriculture	X	X						
Air Quality	X		X	X				X
Utility Demand	X						X	X
Severe Weather Forecasts	X	X	X	X	X	X	X	X
Dam Safety			X	X		X		X
Environmental Concerns	X	X			X	X		X
Hazardous Materials		X						
Forestry			X					X
Fire Weather Forecasts			X					X
Fish/Wildlife	X		X					
Recreation	X	X	X	X	X	X	X	X
Transportation	X							
Skiing								
Sunburn Index	X							
Waste Water Dumping	X							
Building/Construction	X							
Solar Energy	X		X					
TV/ Radio	X		X					
Legal/Forensic Data Base	X	X	X	X	X	X	X	
Pest Plant Management	X							
Water Supply Forecasting	X	X	X	X	X	X	X	X
Hydraulic Design	X	X	X	X	X	X	X	X
Mining (surface)								
NPDES Permits	X	X	X	X	X	X	X	X
Nuclear Plants/Transport		X						
Mud/Landslides			X					

X implies that the flood warning system is used for this alternative use at least annually

These three major groupings of alternative uses could be pursued for the Statewide Network. It should be noted that the Statewide Network will be providing a significant number of opportunities for fee collection from the water related industries. Major suppliers of irrigation water for agriculture and population areas may greatly benefit on a daily basis from the data and information within the system. Water conservation practice relative to recreational use on golf courses may also benefit from the Statewide Network. Water quality studies will benefit from the enhanced knowledge that will accrue within the archive databases.

Operational uses of the weather data within the system could greatly benefit the electrical utility industry both in anticipating and meeting electrical demand within the populated portions of the state. Additionally, this data could be useful in the prediction of air quality related to electrical power generation. A side benefit of the database could assist the National Weather Service in the prediction of severe weather outbreaks within the state. Weather considerations in regard to fire fighting would also be assisted.

Finally, use of the archived data could be made by individuals, universities and businesses to analyze water supply related issues and insurance event reconstructions. University researchers could potentially be aided in obtaining research grants in water-related areas through use of the archived databases. Decisions will have to be made by Arizona on what fees, if any, are to be charged to groups to obtain the data for either operational or archived uses. These issues could assist in the funding of the Statewide Network but considerations will also have to be made to those agencies contributing to the successful operations and maintenance of the Statewide Network relative to the fee structure.

Just as appropriate is the consideration that the Statewide Network can be used as more than a data collection/dissemination network for flooding related issues. Its first alternative use should be to serve as a communication network for E-mail and internal communications between state agencies on a daily basis. This obvious communications use could be overlooked and yet it provides a mechanism for the development of strong allegiance to the network as it develops among a wide user community within Arizona. It is necessary that the Statewide Network's value be recognized on a continuing basis from its initial inception.

While alternative uses and related fee issues will abound, the OCS Mesonet stands alone as a model of how to creatively develop a positive cash flow with an operational data gathering system. A description of the OCS Mesonet and its funding patterns is presented.

The Oklahoma Experience with the OCS Mesonet

The Oklahoma Climatological Survey (OCS) Mesonet has been judged to be the premier mesonet operating in the country. The OCS Mesonet was developed by the state climatologist's office in cooperation with state universities over a period from 1992 to 1994. It officially came on line in March 1994. The primary source of initial funding for the mesonet came from application for $2.0 million of oil-overcharge funds from the U.S. Department of Energy available to Oklahoma and $0.7 million committed by the two state universities to support the design, implementation and operation of the mesonet.

Oil-overcharge funds remain available to states but must be requested through proposals related to energy conservation. Arizona should investigate both the availability and the application procedure for similar oil-overcharge funds to support the initial costs of the Statewide Network. Additionally, the OCS published a monthly and quarterly Mesonet Update newsletter to promote interest and political support in the potential mesonet user community as the system was being designed and implemented. This newsletter was identified in Oklahoma with playing a major role in the securing of funds and political votes needed to support the mesonet in the Oklahoma legislature.

The key system attributes of the OCS Mesonet are listed below:

- 111 automated environmental monitoring stations are spaced evenly across state (40km). See Figure 6.
- Each station reports every 15 minutes relayed through the Oklahoma Law Enforcement Telecommunications System (OLETS) to a central processing unit (CPU) at OCS via radio/landlines.
- The CPU ingests data, manages the database, quality controls and generates/disseminates products. The data and products are disseminated through a computer bulletin board with 11 telephone line (voice grade) access by modem or on three dedicated high speed (T1) lines to federal and state agencies. Over 100,000 requests for information are processed monthly as of October 1994 with over a million annual requests for data or mesonet products expected in 1995. See Figure 7.

- The CPU ingests NOAA Weather Wire, i.e., NWS zone forecasts, observations, severe weather watches, statements and warnings, in addition to the raw observations from the mesonet environmental stations.

- Dual CPU systems exist at OCS in Norman and at Oklahoma State University in Stillwater for redundancy and database preservation.

- While the mesonet was not designed as a flood warning system, it is used extensively by NWS for flash flood watch and warning dissemination , flood/precipitation verification and NEXRAD radar precipitation product bias calculation.

Two functions of the mesonet are **service** and **public relations**. Service functions focus on government agencies, public/private schools and for-profit businesses. Public relation functions focus on public access to the mesonet through interactive kiosks located at the State Capitol and on the University of Oklahoma and Oklahoma State University campuses.

The attributes of the OCS Mesonet should be seriously considered for inclusion in the final concept design of the Statewide Network. The OCS Mesonet's key characteristics and their applicability to the Statewide Network are listed below:

- System was initially **designed for specific/alternative uses.**

- Input/output products consist of mesonet-generated and NWS data/products.

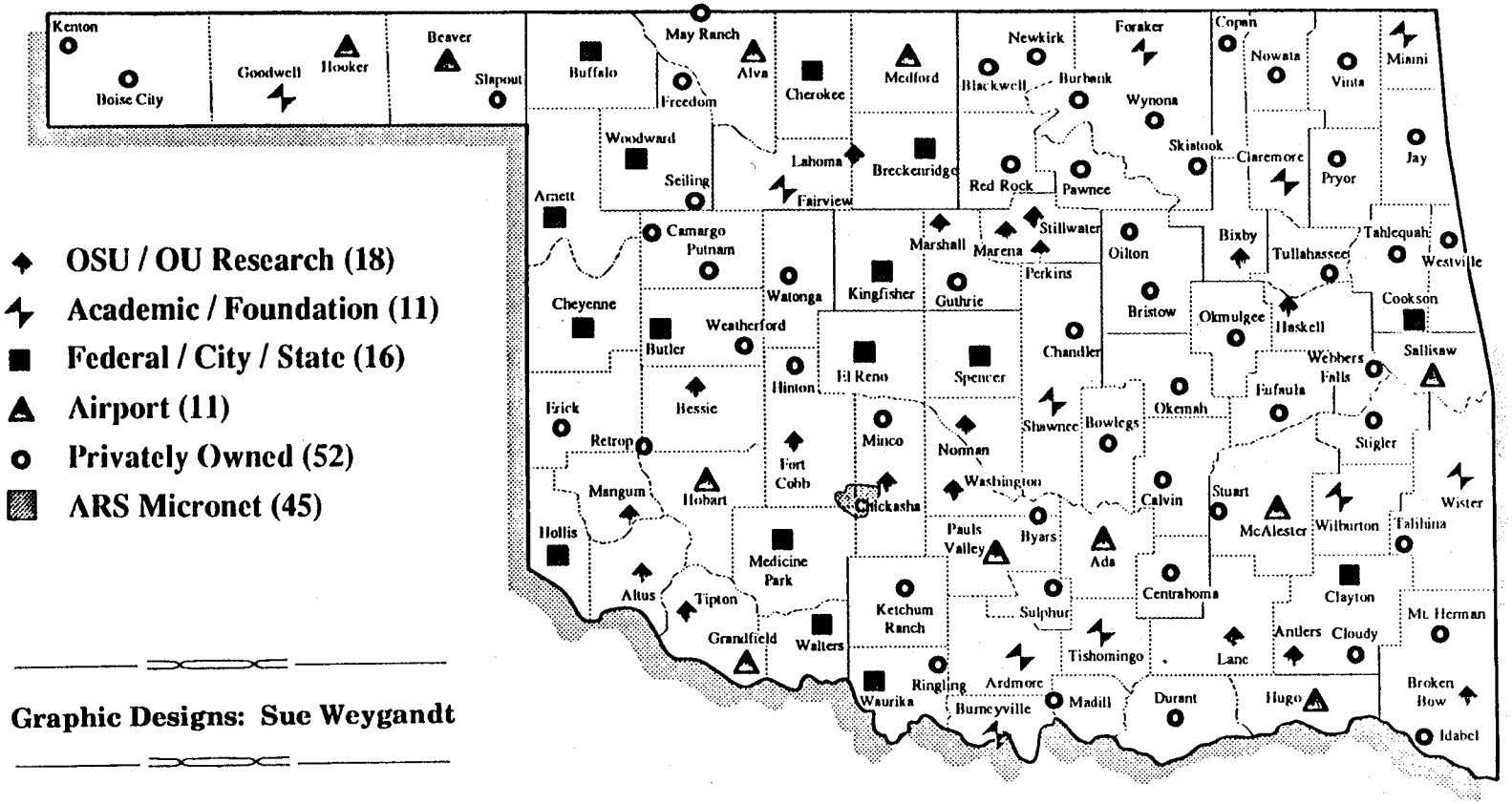
- Primarily a **data** and **educational resource.**

- **Redundant** CPU's are located at **state facilities** to preserve and control the data base.

- Generates approximately $4.0 million per year in **educational grants.**

- **Estimated to save $7.0 million per year in irrigation, agriculture and energy costs.**

- System cost was approximately $3.3 million to install and design and $800,000 to maintain.



Photographs of wheat harvest, controlled burn (cover) and crop-dusting plane (page 9) are courtesy of the Department of Agricultural Communications, Oklahoma State University.

FIGURE 6

Location of Mesonet Sites (Land Ownership)

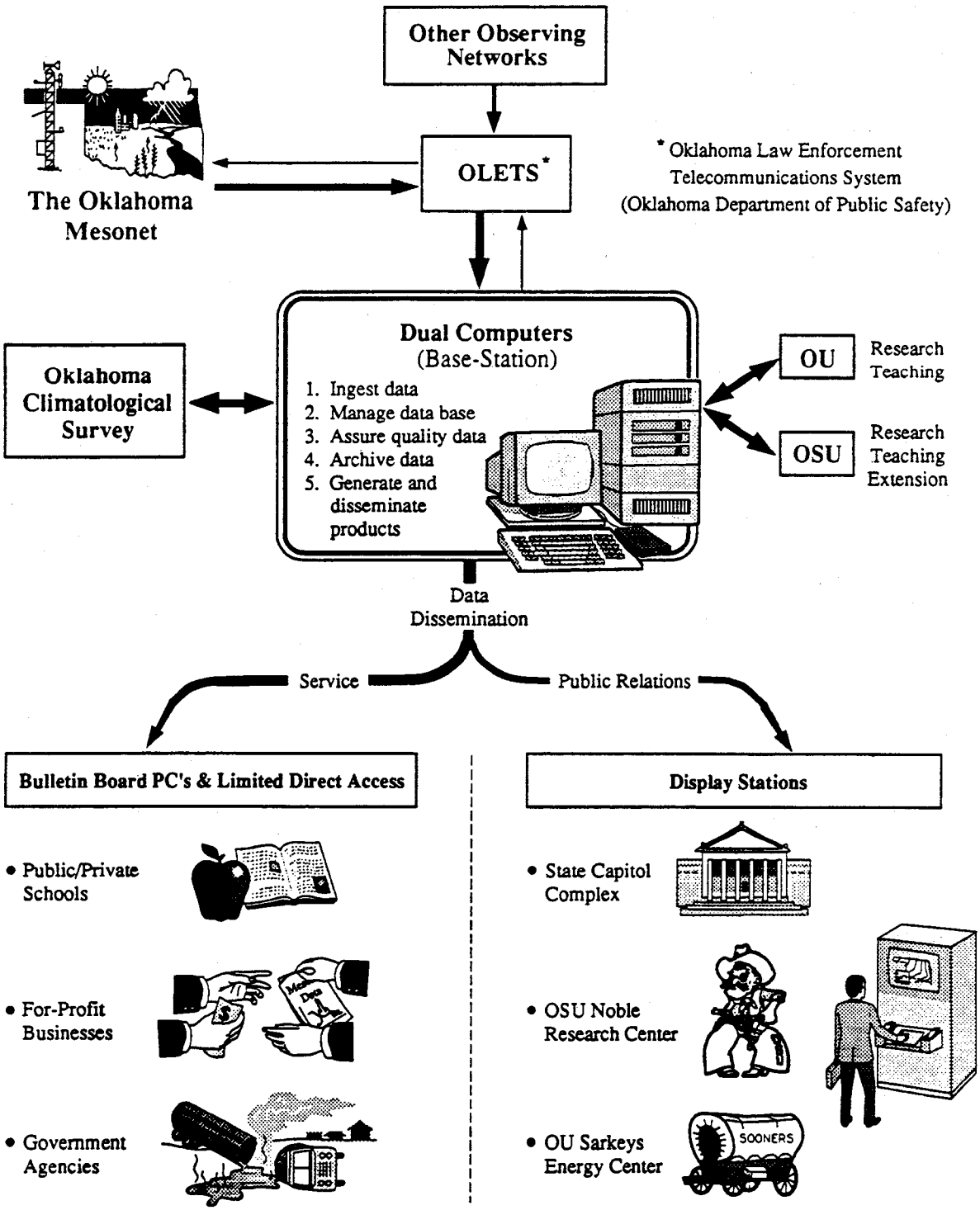


FIGURE 7

Data Transfer Via OLETS
Through the Mesonet Base Station to a Large, Statewide Community of Users

Clearly, the OCS Mesonet is a money maker for Oklahoma while providing a crucial environmental contribution to the public and business communities. Arizona could conceivably apply for the same oil-overcharge funds through energy conservation proposals generated by universities and other entities if it wishes to develop a Statewide Network as a flood warning system with alternative uses. The benefits to Arizona could be similar to those of Oklahoma, especially to the university research and educational communities located in Phoenix and Tucson.

Arizona should also design a redundant central processing unit system similar to Oklahoma's to insure that the database will be protected and available during severe weather situations and to assist in data/product delivery. The location of this CPU at a state agency or similar governmental facility is noted as a means for Arizona to maintain control over the database, reduce costs and maximize returns to the state of Arizona and the users of the system.

A Potential Arizona Application

The Oklahoma investment in its mesonet was designed from its inception to provide an environmental database for alternative uses and for research and development uses. At present, Arizona should consider strongly the continuing value to the state of cautiously expanding the scope of the Statewide Network into a multi-use environmental network which could serve to enhance the self-sustaining Arizona flood warning system to the benefit of the entire state. A basis for this consideration is presented.

The gradual expansion of the Statewide Network into alternative uses could be accomplished over the near future after the initial network is developed for flood warning activities. The network could use the OCS Mesonet as an example and with time the network could develop into a significant state resource and money-maker. The suggested name of the network, AIRE, relates to the proposed uses listed below:

A: Arizona Agricultural

I: Information

R: Research and Recreation

E: Education and Environment.

The AIRE network could be envisaged as a network of 108 environmental data gathering stations instrumented similar to the OCS Mesonet but drawing on the existing Statewide Network locations. The 108 sites could be placed in a pattern shown in Figure 8 which covers the major populated portions of the state. The stations are spaced in an organized network every 20 miles stretching from Flagstaff on the north to Nogales on the south and from Salome on the west to Duncan on the east. The network is distributed into four sub-regions as indicated in Table 6.

TABLE 6

A Listing of the Sub-Regions, Number of Environmental Sites and the Area Covered for the AIRE Network

Sub-region	No. of Stations	Area covered (sq. mi.)
(1)	(2)	(3)
I - Flagstaff	25	6,400
II - Phoenix	42	12,000
III - Safford	30	10,000
IV - Tucson	11	3,500
	108	31,900

The 108 station AIRE network would be similar to the 111 stations in the OCS Mesonet and would cost about $1.75 million to establish with savings based on the assimilation of the AIRE network information into the Statewide Network. Since major population sources are found in sub-region II (Phoenix) and sub-region IV (Tucson), these two portions of the network could be considered first for funding.

The AIRE network is not intended to replace the need for a field gage network which is site-specific based on hydrologic criteria for flood warning purposes. Rather, the AIRE network is intended to augment the Arizona flood warning system by providing mesonet environmental data to supplement the prediction and detection components of the flood warning system. Additionally, the AIRE network would enhance the opportunities to develop alternative uses for the flood warning system, thereby increasing the level of funding available for the system to be self-sustaining and potentially economically beneficial to Arizona users.

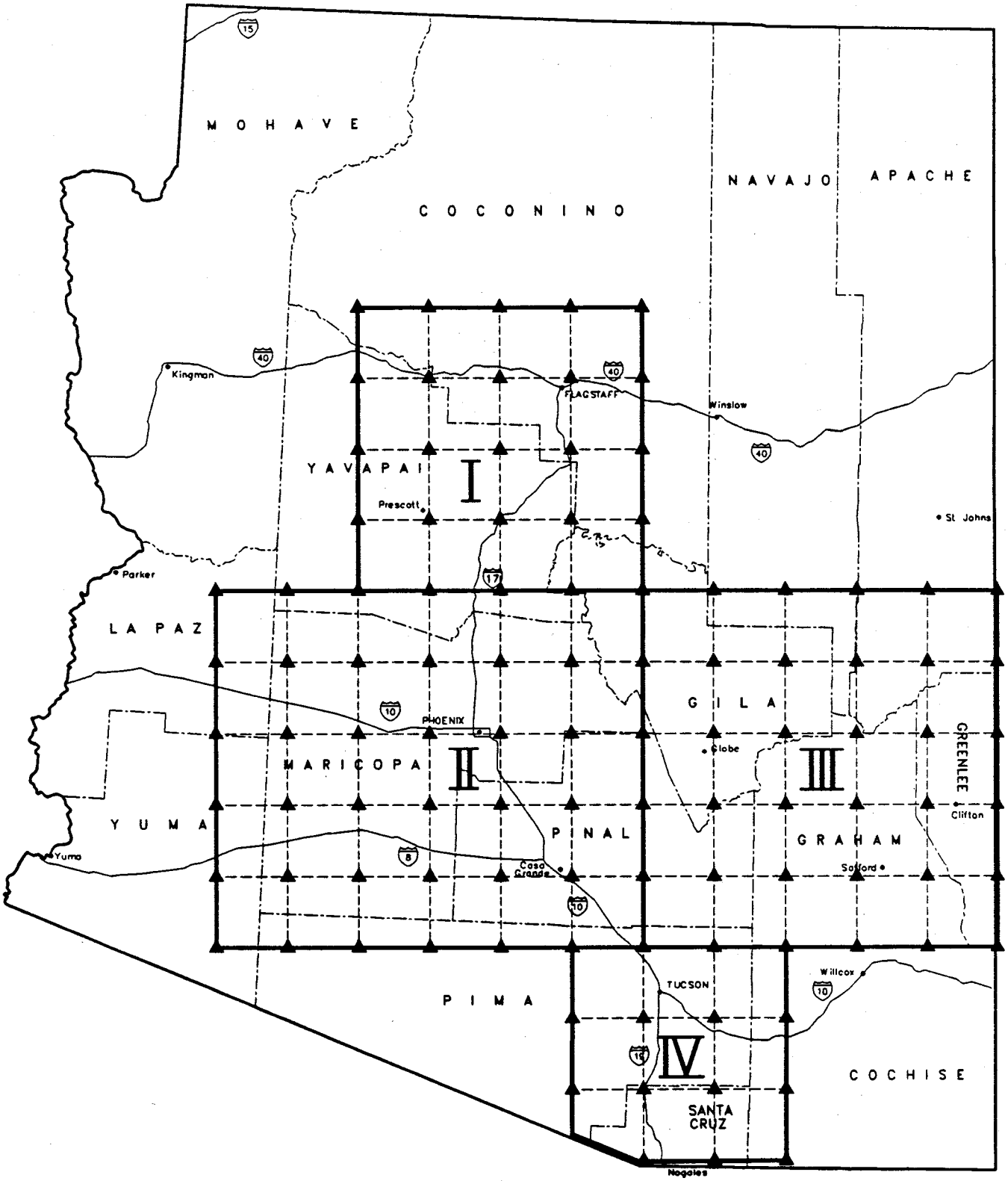


FIGURE 8

The AIRE Network Station Distribution

The AIRE network would focus on the areas of education, environment, agriculture, research and information to generate funds. The education thrust could focus on providing data streams to K-12 grades in Arizona schools. Application to the NSF EARTHSTORM project might be able to provide initial funding to place computers with modem access to the network into schools. Curriculum could be developed which use the data. The American Meteorological Society is spearheading a thrust to working with education at this time that is receiving national interest and support. Arizona could capitalize on this opportunity if the educational community chooses to become involved.

The environmental aspect of the network could focus on assisting in the prediction of air quality issues related to electrical energy generation and the mining air pollution issues which abound. The network would provide an unprecedented opportunity to monitor air movement and initialize air quality models assisting the state in monitoring this important issue. The utility industry might also participate in the maintenance of the network through fees related to air pollution contributions.

The obvious benefits to agriculture should provide a boost to the state's economy. The use of wind information to assist in pesticide application, soil moisture monitoring to aid irrigation management and temperature/precipitation prediction are easy to comprehend.

The state's universities could see the network assist them in applying for research grants similar to the experience of the University of Oklahoma and Oklahoma State University when they made use of the OCS Mesonet in its research applications. The potential research funding increase to the state might be enough to offset the entire operating budget needs of the AIRE network.

While it is not a focus of this report to describe the opportunity in detail for the alternative uses of the Statewide Network it is believed that a compelling opportunity is presented to Arizona. It is worthy of an additional follow-up study to check the validity of the assumptions and utilization of the alternative uses that have been briefly outlined in this report.

IMPLEMENTATION

The implementation of the concept design of the Statewide Network is the initial step in a long-range process of full development of the Arizona flood warning system and potentially a multi-use AIRE environmental network for the State. This section presents a framework for this evolutionary process from the current status of flood warning in Arizona toward the goals of an effective, self-sustaining flood warning system augmented by an environmental mesonet with many alternative uses. Clearly, this process will require focused vision and leadership from the Network Committee members and other state organizations if the goals are to achieve fruition.

Implementation of Statewide Network Concept Design

A concept design of the Statewide Network is presented in a preceding section of this report. The hardware and software that comprise the conceptual design combined with the existing hydrologic data collection systems are both adequate and complete to serve as the backbone of a statewide flood warning system. Should Arizona decide to proceed to final design, the hardware and software infrastructure would be complete. However, hardware and software are not all that is needed to have a flood warning system. There is considerable human organization and response planning that are required if Arizona is to turn a state-of-the-practice communication and instrumentation system into a flood warning system. A spatial schematic representing the implementation process is shown in Figure 9. It is evident that achieving the full development of the Arizona flood warning system will require layering each of the components upon the foundation of the current state of flood warning capability in Arizona afforded by the existing ALERT systems and local flood warning plans.

As shown in Figure 10, the implementation of the Statewide Network concept design should be guided by its impact on the development of the Arizona flood warning system and the implications of alternative uses of the Statewide Network to provide a source of system funding. Much of the focus of implementing the Statewide Network initially centers on strengthening the communication component of the flood warning system. A major factor in providing the momentum and resources necessary to mobilize the initial push toward network installation is the outcome of the COE Arizona Flood Control Study. The COE requires that its design provides complete, "stand alone" flood

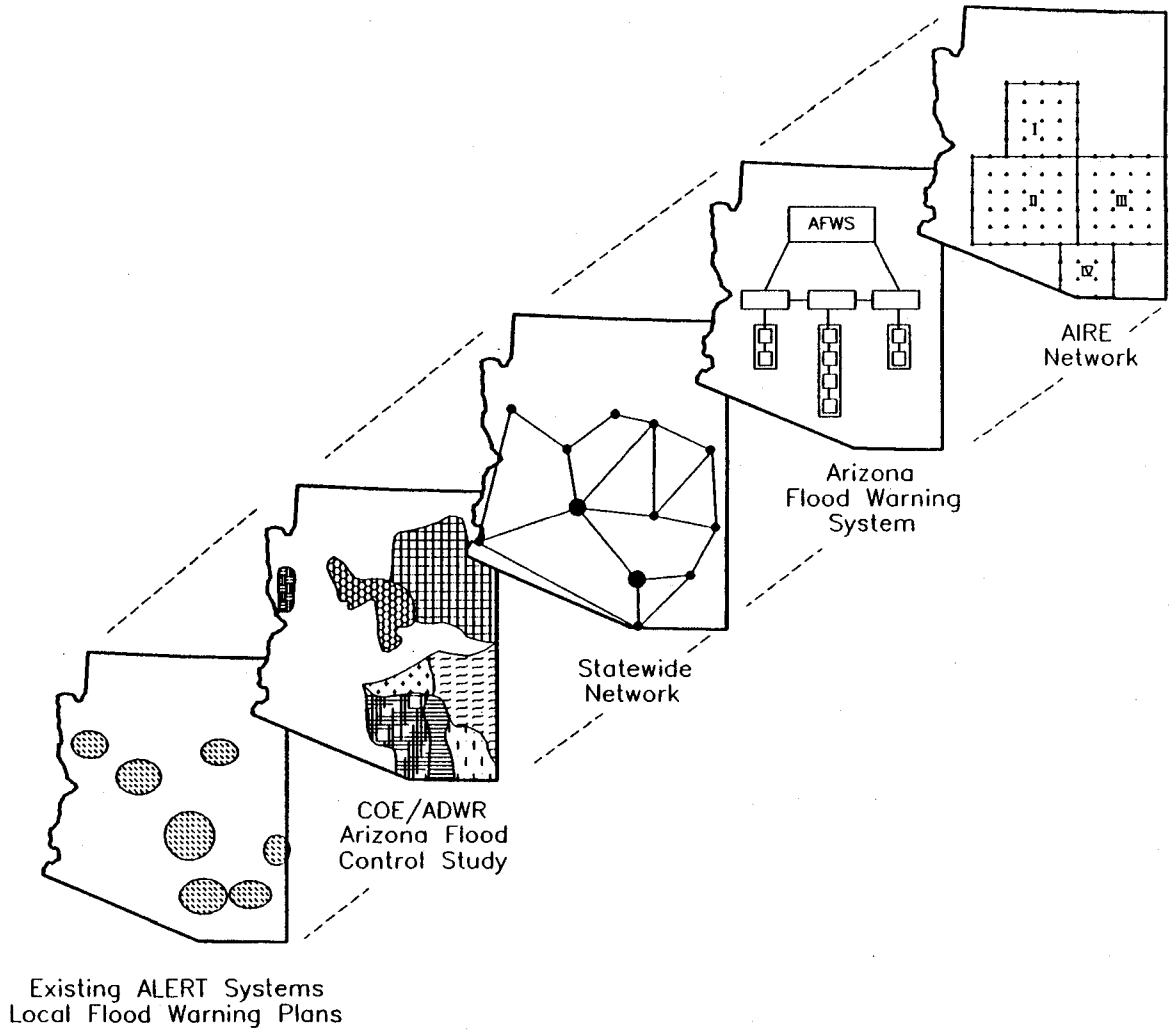


FIGURE 9

Spatial Schematic of Implementation Process

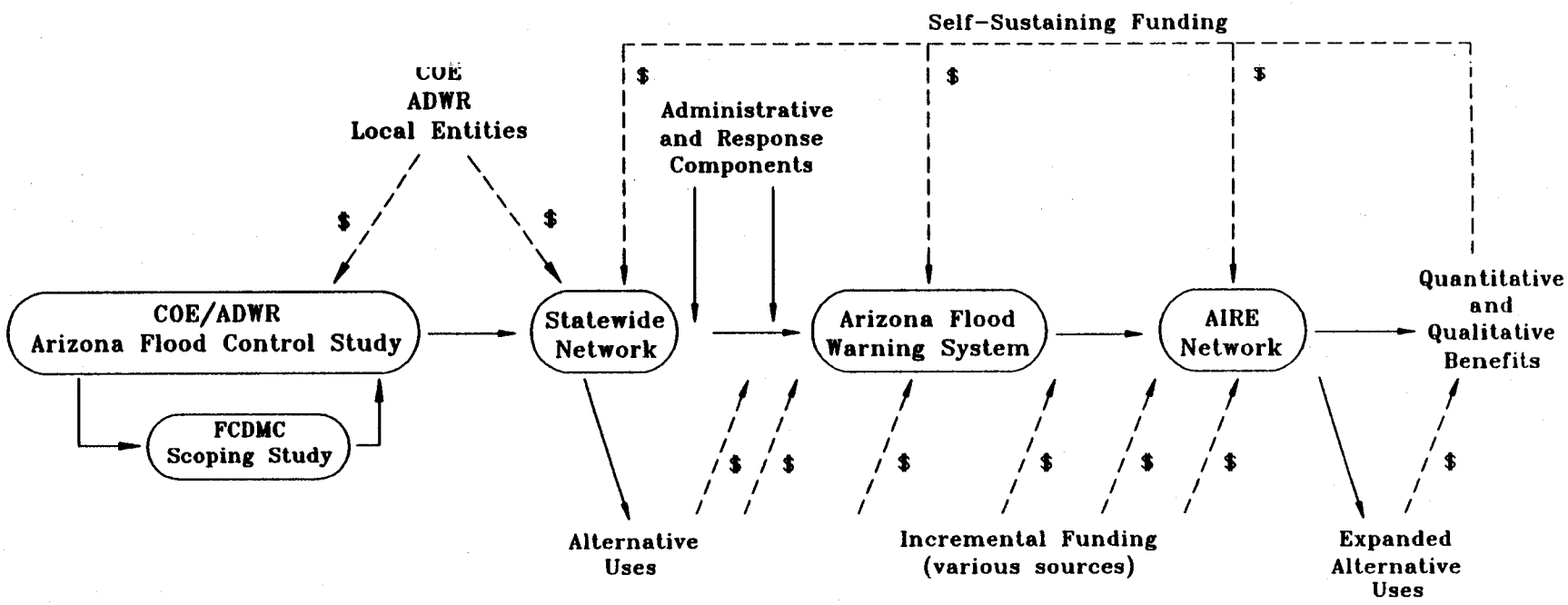


FIGURE 10

Temporal Schematic of Implementation Process

detection, communication, and computational capability for flood warning purposes. The COE study recommends the allocation of significant funding (with cost sharing by ADWR) for the design and installation of hardware/software necessary to network ALERT and other data collection systems into five regional base stations located statewide and, thereby, into a central computer facility presumably located in Phoenix and managed by ADWR.

It is envisioned that the proposed COE flood warning system will be the backbone of the Statewide Network and will accommodate later expansion as the Statewide Network develops. This involves the installation of the necessary hardware/software to effectively tie-in additional data collection sensors in other basins, provide additional communication capability, and provide system redundancy as recommended.

Beyond the actual hardware for the detection, communication and prediction functions of the Statewide Network, what is clearly lacking is the human infrastructure necessary to implement and execute the planning and response components vital to the development of the Arizona flood warning system. The Statewide Network itself has the capability to support alternative uses unrelated to flood warning as previously discussed in this report, which could generate funds to facilitate the growth in the administrative and response branches necessary for a fully developed flood warning system. At this time, the ADWR Flood Warning System Fund is available to support the development of a statewide flood warning system by providing assistance to local entities for planning, design, installation, operation and maintenance of local flood warning systems. Given adequate resources, concurrent implementation of both the Statewide Network infrastructure and the human organizational components would optimize the process of development of the Arizona flood warning system.

Potential Arizona Flood Warning System

The diagram in Figure 11 organizes the federal, state, county and local government agencies currently participating in flood warning activities in Arizona into a state flood warning system and its components. While Figure 11 is not intended to be all inclusive, most government agencies can find the appropriate place for their current activities. Note that no formal state flood warning system organization currently exists though a loose structure has already begun to emerge. Several key observation are apparent:

- The existing ALERT networks and other data collection sensors provide a foundation for further development of the **detection component** of the Arizona flood warning system.

- **The COE Arizona Flood Control Study is an essential element in the implementation of the Statewide Network.** Local sponsorship of the COE Study by ADWR indicates a strong commitment to long-term development of effective flood warning capability on a statewide basis.

- Demonstrated cooperation between agency members of the Network Committee and the Arizona ALERT Users Group is evidence of increasing momentum behind the effort to develop an effective, efficient Arizona flood warning system.

- No lead agencies are currently heading the branches or performing the duties of the administrative, operational or response branches of a state flood warning system. In short **leadership roles need to be defined for a state flood warning system to evolve.** It appears ADWR is a logical candidate for assuming a leadership role.

- Each of the flood warning system components are actively represented by all levels of government. **No additional agency formation is needed.**

- The **Statewide Network should act as a focal communication point** for the coordination of the Arizona flood warning system activities and decision-making.

- A **state flood warning plan** which links the branches and components of the flood warning system into a coordinated activity **does not exist** in its entirety, but is beginning to evolve.

- A consistent **funding source** for the Statewide Network and Arizona flood warning system **does not exist.** Through the recent passage of budgetary appropriations to ADWR, the Legislature has committed to continuing support during the next two years.

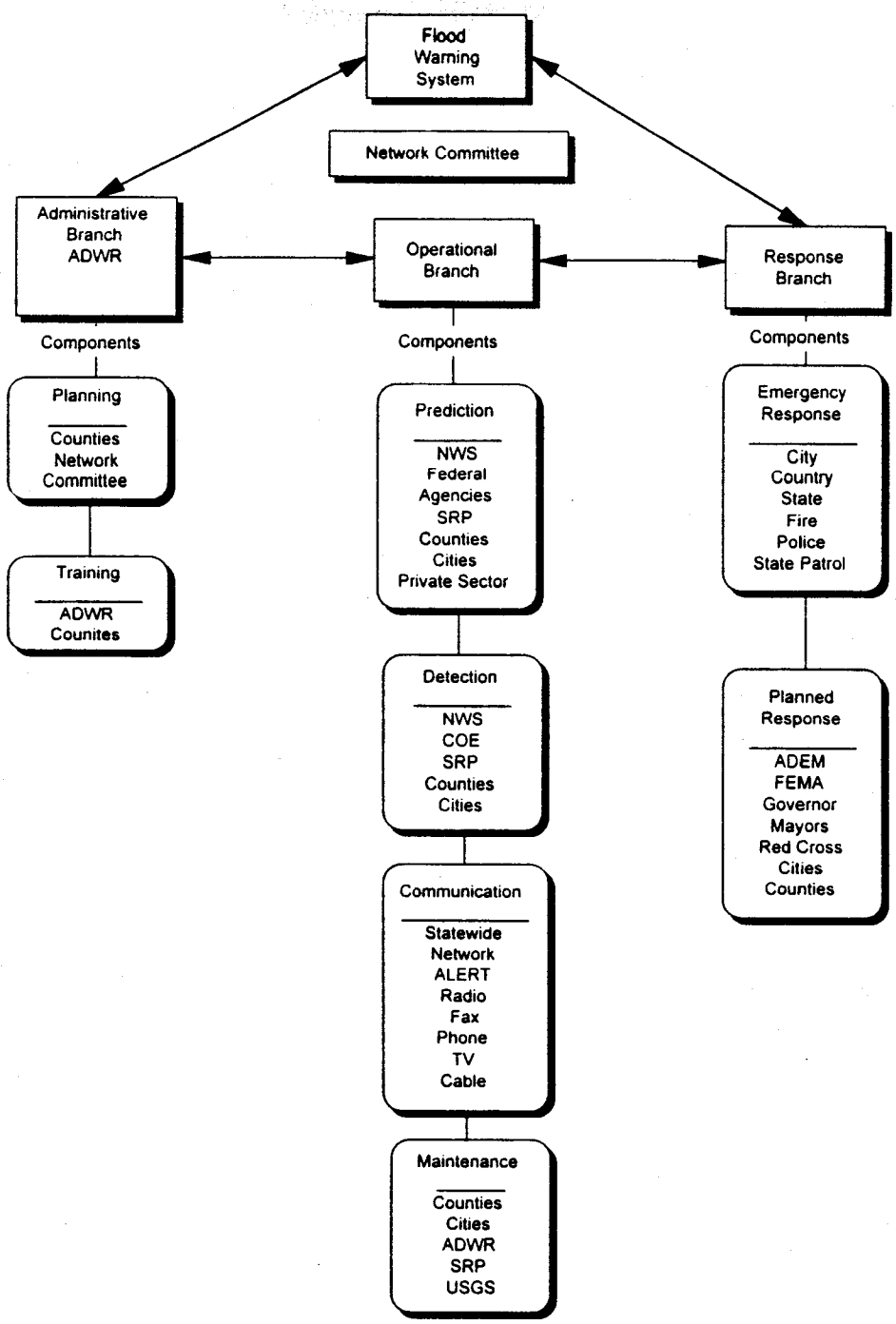


FIGURE 11

Potential Arizona Flood Warning System

It is clear from these points that the formation of a functioning flood warning plan and state warning system will require the identification of a lead administrative branch agency and possibly a lead response branch agency. The lead administrative branch agency will be the visionary group which provides the leadership to develop a state flood warning plan which can harness the energies and abilities of the component agencies into a functioning state warning system. Additionally, the staff and funding for these functions will need to be acquired. The operational branch of the flood warning system may need to be administered by the administrative branch to insure that the needs of the users are being met in prediction, detection, communications, and maintenance to provide fiscal support as needed.

It is apparent from interviews within the state that no agency which can meet these requirements with existing staff has emerged. By means of legislative budgetary appropriations, ADWR has started the process of assembling the staff necessary to support several functions. The state and Network Committee may require additional assistance in formulating and structuring the state flood warning plan and identifying the lead branch level agencies needed. Additionally, the development of funding for the Arizona flood warning system through alternative uses of the Statewide Network should be considered as previously described.

Expansion of the Arizona Flood Warning System

The gradual expansion of the Arizona food warning system to include the AIRE environmental monitoring network has been previously discussed. Using the OCS Mesonet as a model, the AIRE network could supplement the detection and prediction components of the flood warning system. Equally important, the implementation of the AIRE network could widely increase the spectrum of alternative uses for the system to the point of generating a level of funding sufficient to be self-sustaining and potentially economically beneficial to Arizona users.

Again, learning from the Oklahoma experience, Arizona should investigate the same source of initial funding from the oil-overcharge funds from the U.S. Department of Energy to generate the resources necessary for installation and start-up expenses. The AIRE network would focus on the areas of education, environment, agriculture, research and information to generate additional operating funds.

Qualitative Benefits

The goals of the Statewide Network and of a planned, gradually executed implementation of an Arizona flood warning system are to provide sufficient qualitative benefits to Arizona to justify the resources required to initialize the process. Major benefits include:

- Effective and efficient statewide flood warning that results in savings of life and property.
- Self-sustaining funding with the potential for significant return on the initial investment.
- Opportunity for expanding and upgrading the system as resources and technology progress.
- Maintaining user familiarity through training and alternative uses.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

There are numerous conclusions that are derived from this project about flood warning systems and data collection/dissemination networks, in general. However, the following are the major conclusions specifically regarding the Statewide Network.

1. Experience gained during the 1993 floods in Arizona clearly indicated that the existing structure for communication of vital data and information during flood events is extremely complex and inefficient. The scoping study verified that **neither an effective information communication system nor a flood warning system exist in Arizona** and this contributed to the 1993 flood communications problems.

2. The organizations forming the Network Committee are working effectively to provide the foresight and direction to initiate a Statewide Network. However, **no single organization within Arizona has the mission, funding mechanism, and technical expertise that is needed to design, implement, maintain, and operate the Statewide Network.** ADWR is beginning the process of assembling the necessary funding and staff to support the development of the Statewide Network.

3. There are **two distinct tiers of users in Arizona of the Statewide Network**; agencies with full-time staffs dedicated to hydrology and water management, and agencies whose primary function is broadly defined and for whom flood response is considered on an as-needed basis. Because the second tier agencies are often the ones who maintain the basin instrumentation, the situation exists where those who produce much of the most timely flood detection data are the least sophisticated in its use and interpretation. This conclusion is a major factor in the concept design.

4. A complete and effective flood warning system is composed of several components, all of which are necessary. The Statewide Network is a vital component and is a logical focal point for initiating an Arizona flood warning system, but the **Statewide Network does not constitute a flood warning system by itself.**

5. **There is a wide base of support throughout the state for the Statewide Network and ultimately for an Arizona flood warning system.**

6. **A funding mechanism for the Statewide Network does not exist** although initial funding has laid the groundwork for such a network. Recent budgetary appropriations by the Legislature to support ADWR Flood Warning Office staff and funding programs are a positive indication of continued financial support at the state level.

7. Successful flood warning systems either have a legislated funding mandate, or generate funding through alternative uses, or use a combination of public and private sector funding sources.

8. The concept design of the Statewide Network is based on the need for flood management; however, there are many other uses for a system of this power and flexibility. These **alternative uses will form the backbone of the system's daily use and are a potential source of continual maintenance and operation funds.**

Recommendations

Recommendations are provided in five categories. Within each category, specific action items are suggested to bring about the Statewide Network and to progress toward a fully functional and effective Arizona flood warning system.

Organization and Administration

1-1. The Network Committee needs to designate a **lead agency** for the administration of further work on the Statewide Network. In view of previous legislation which resulted in the Arizona Flood Warning Office within ADWR and recent legislative support in regard to expanded flood warning responsibilities by ADWR, it is logical that ADWR assume that function, if it already has not done so.

1-2. The Network Committee should continue to function as a focal point for the numerous agencies to **formulate a plan of action** that will achieve the implementation of the Statewide Network and ultimately an Arizona flood warning system. That plan must consider all of the components of successful flood warning

systems. That plan will need to be flexible because of uncertainties in regard to available resources (funding, staff, etc.), but should be specific in regard to achieving specified **goals**. That planning should be undertaken by the Network Committee itself or it can be contracted by the lead agency.

1-3. The Network Committee should enter into **agreements** to achieve the interim funding and staff support that will be necessary to **execute the plan of action** from Recommendation 1-2.

1-4. The Network Committee should progress to **establish the Administrative Branch of the Arizona flood warning system**. That branch will initially be responsible for implementing the construction of the Statewide Network and would pursue attracting alternative uses and the ultimate development of the Arizona flood warning system. The responsibilities of the Network Committee would be assumed by the Administrative Branch, and the Network Committee would continue to serve in an advisory capacity to the Administrative Branch.

Funding

2-1. The **U.S. Army Corps of Engineers' (COE) Arizona Flood Control Study** project should be actively pursued to provide a **funding mechanism** for much of the Statewide Network and to form the backbone of an Arizona flood warning system.

2-2. **Funding from the Arizona legislature is crucial** to obtain matching funds for the COE project and for the continued operation of the Arizona Flood Warning Office of ADWR. Legislative funding may also be necessary for at least the implementation and start-up costs of the Statewide Network.

2-3. The availability of U.S. Department of Energy **oil-overcharge funds** should be investigated, and, if available, proposals should be prepared by eligible agencies that can assist in the expansion, operation, maintenance and sustaining funding of the Statewide Network.

2-4. **Funding opportunities by alternative uses** of the Statewide Network and/or the proposed AIRE network should be pursued. Such funding opportunities may provide the sustaining funds for the system.

Final Design of the Statewide Network

3-1. The final design of the Statewide Network should be initiated. It is unlikely that this can be done by the Network Committee itself or any of the Network Committee members. It will probably need to be performed by contract, and can be expected to cost about $200,000. The firm that is chosen should have experience in database design, data communications, interface design, client-server application programming, and computer security along with hydrometeorology, and flood warning systems. Detailed design should include:

- An implementation plan that will proceed from the current base of installed equipment to the fully functional network.
- Intermediate steps that will gain the state some functionality short of the fully developed statewide web.
- Hardware design specification.
- Specification for special purpose software to construct and display a basic suite of products.
- A detailed design of the four logical databases described in this report.
- Communication link specification between the nodes.
- A detailed cost estimate for software, hardware, communications and maintenance.

Alternative Uses

4-1. An organized and concerted effort must be made to **attract alternative uses** for the Statewide Network. This is vital not only in terms of **potential funding** but also in regard to satisfying the **training component** of a flood warning system. This should begin as soon as possible.

4-2. There is potentially a substantial source of funding that may be available through **education** and **research grants**. Special efforts must be made to introduce the opportunities that are presented by the Statewide Network to universities, education groups, and state-wide research organizations.

4-3. A **newsletter** should be initiated to obtain political, financial and alternative use support for the Statewide Network and an Arizona flood warning system. That newsletter should be widely distributed to all the counties, municipalities, universities, research organizations, water and environmental agencies, educational groups, etc. It should be written to **showcase the capabilities and strengths of the system and to recommend uses.**

4-4. It is not likely that the Network Committee or its members will have the staff or resources to undertake Recommendations 4-1 through 4-3. Those recommendations can have high return on the investment and those activities and related functions in support of the Network Committee's goals should be contracted to a broad-based firm or team with qualifications in research, education, hydrometeorology, flood control, agriculture, environmental programs, marketing, and public relations.

Implementation of an Arizona Flood Warning System

5-1. The **detection component** of a flood warning system needs to be strengthened statewide. Strategically placed ALERT networks are needed throughout the state.

5-2. A broad spectrum of **planning** is needed. This planning will initially come from the Network Committee (see Recommendation 1-2). It would then be conducted by the Administrative Branch (see Recommendation 1-4 and Figures 2 and 10).

5-3. The Statewide Network will be a powerful and complex system, whose primary function will be needed infrequently. Insuring that the system's users will be able to quickly draw the proper inferences and perform the correct actions during a flood will require **carefully designed training**. It is recommended that this training function be approached from two directions. The direct approach is to design frequent **exercises of the system**. These exercises should take the form of role playing and should use the actual system to project the scenario to all of the players. These exercises can optimistically be expected to occur no more than twice a year. Such frequency is insufficient to maintain the proficiency that would be needed during an actual flood. This brings forth the second approach to training which is through **alternative uses**. The Statewide Network will contain information that can be used

by numerous users on a daily basis for economic, research and educational purposes. To the extent that these alternative uses can be made widely available, they will promote a general familiarity with the layout and functions of the system. That familiarity will pay large dividends during an emergency.

5-4. The **prediction component** of the flood warning system will need to be enhanced. This should be provided by value-added products to the existing flood warning products. Specifically, basin-specific qualitative precipitation forecasts are needed.

5-5. The **response components** of flood warning will need to be strengthened through **experience, planning,** and in **training** in the use of the Statewide Network.

5-6. There is potentially a cost-savings, through cooperative agreements, to be realized in utilizing agencies, such as the USGS, with an existing capability in the maintenance of hydrologic data collection hardware and software to perform similar **maintenance** functions for the Arizona flood warning system infrastructure.

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APPENDIX A

INVENTORY OF ARIZONA HYDROMETEORGOLOGICAL DATA COLLECTION STATIONS

Note: This inventory was provided by ADWR and contains information collected from multiple sources. Included are all known data collection stations within Arizona as of February 1995; however, the information has not been reviewed for accuracy.

TABLE 1

ABBREVIATIONS USED IN STATION NAMES

AP = Airport
CC = Country Club
CH = City Hall
CN = Canyon
EF = Experimental Farm
FC = Flood Control
FD = Fire Department
FFS = Fire Fighting Station
FH = Fish Hatchery
FS = Fire Station
FSS = Flight Service Station
FR = Fire Road
FW = Fire Warden
GS = Guard Station
HMS = Highway Maintenance Station
HQ = Headquarters
LC = Land Company
LO = Look Out
LWR = Lower
MO = Monitoring Outpost
NM = National Monument
NP = National Park
PH = Power House
PO = Post Office
PP = Pumping Plant
PS = Patrol Station
R = River
RAWS = Remote Automated Weather Stations
RG = Rain Gage
RS = Ranger Station
SD = Storm Drain
TP = Trading Post
WB = Weather Bureau
WS = Weather Station

TABLE 2A

PARAMETERS

"Pt" = pressure transducer
"Te" = air temperature
"Pr" = precipitation
"Ev" = evaporation
"Ws" = wind speed
"Wd" = wind direction
"Rh" = relative humidity
"Dp" = dew point
"Bp" = barometric pressure
"St" = soil temperature
"Sr" = solar radiation
"Ot" = other

TABLE 2B

CHARACTERS UNDER OTHER

"1" = Snow Course
"2" = Snow Pillow
"3" = Duration of Sunshine
"4" = Water Elevation
"5" = Water Temperature
"6" = Duration of Precipitation
"7" = Standard Deviation of Wind Velocity
"8" = Water quality
"9" = Air Quality
"o" = Battery Status
"a" = Stage
"b" = Gage Elevation
"c" = Reservoir Storage
"d" = Snowfall and Snow on the Ground

TABLE 3

AGENCY ACRONYMS, INITIALS, OR ABBREVIATIONS

ABSC	=	American Beet Sugar Company
ADWR	=	Arizona Department of Water Resources
AWW	=	Anaheim Water Works
AZMET	=	Arizona Meteorological Network
BIA	=	Bureau of Indian Affairs
BLM	=	Bureau of Land Management
CBG	=	California Botanical Gardens
CCFCD	=	Clark County Flood Control District
CDF	=	California Division of Forestry
CDPR	=	California Department of Parks & Recreation
CDWR	=	California Department of Water Resources
CIMIS	=	California Irrigation Management Information System
CLIM	=	National Weather Service Climatological Station
COACH	=	Coachella-Riverside ALERT Network
COE	=	Corps Of Engineers
CVWD	=	Coachella Valley Water District
CYPRUS	=	Cyprus Copper Mine
DFWL	=	Department of Fish and Wildlife
DPCP	=	Dos Picos County Park
DOE	=	Department Of Energy
DRI	=	Desert Research Institute
GCES	=	Gila County Emergency Service
FAA	=	Federal Aviation Administration
FTAP	=	Fort Apache
GBAPCD	=	Great Basin Air Pollution Control District
HCP	=	Heise County Park (San Diego)
HELIX	=	Helix Irrigation District
IBWC	=	International Boundary & Water Commission
KCDPW	=	Kern County Department of Public Works
KCFC	=	Kern County Flood Control
KCFD	=	Kern County Fire Department
KCRM	=	Kern County Resource Management
KCWA	=	Kern County Water Agency
KRCO	=	Kern County
LACDPW	=	Los Angeles County Department of Public Works
LACDWP	=	Los Angeles County Department of Water & Power
LACFCD	=	Los Angeles County Flood Control District
LACFD	=	Los Angeles County Fire Department
LACO	=	Los Angeles County
LACY	=	Los Angeles City
LAFD	=	Los Angeles City Fire Department
LA STORM	=	Los Angeles Storm Warning
LAWD	=	Los Angeles Water Department
LBAP	=	Long Beach Airport
LBCTY	=	Long Beach City
LTI	=	Little Tujunga Indians
MCFCD	=	Maricopa County Flood Control District
MEDA	=	NWS Meteorological Data Station
MWC	=	Municipal Water Company
NCE	=	Nevada Cooperative Extension

NOAA	=	National Oceanic and Atmospheric Administration
NPS	=	National Park Service
NSO	=	National Weather Service Neclear Support Office
NWS	=	National Weather Service
OBSERVER	=	Observer owns and reports voluntarily
OCDPW	=	Orange County Department of Public Works
OCEMA	=	Orange County Environmental Management Agency
OCFC	=	Orange County Flood Control
OC&SFCD	=	Oak Creek & Sedona Flood Control District
OGA	=	Orange Growers Association
PCC	=	Peabody Coal Company
PCFCD	=	Pima County Flood Control District
PCP	=	Potrero County Park (San Diego)
PDMWD	=	Padre Dam Municipal Water District
PHXFD	=	Phoenix City Fire Department
PRIVATE	=	Privately Owned
PWD	=	Pasadena Water District
RCFC	=	Riverside County Flood Control
SAFD	=	Safford District, BLM (Arizona)
SANCY	=	San Diego City
SBCDOT	=	San Bernardino County Department of Transportation
SBCFC	=	Santa Barbara County Flood Control
SCAQMD	=	South Coast Air Quality Management District
SCE	=	State Cooperative Extension
SCECORP	=	Southern California Edison Corporation
SCGCO	=	Southern California Gas Company
SCO	=	State Climatology Office
SCS	=	Soil Conservation Service
SDCDPW	=	San Diego County Department of Public Works
SDCFC	=	San Diego County Flood Control
SDCFD	=	San Diego County Fire Department
SDCP	=	San Dieguito County Park (San Diego)
SDFD	=	San Diego City Fire Department
SDID	=	San Dieguito Irrigation District
SEWPC	=	S.E. Water Pollution Control
SNWS	=	Southern Nevada Water Systems
SPRR	=	Southern Pacific Rail Road
SRP	=	Salt River Project
SWEET	=	Sweetwater Authority
UCAG	=	University of California Agriculture
UCLA	=	University of California Los Angeles
UNKNOWN	=	Agency was not provided
USAF	=	United States Air Force
USBR	=	United States Bureau of Reclamation
USCG	=	United States Coast Guard
USED	=	United States Engineering Department (COE)
USFS	=	United States Forest Service
USGS	=	United States Geological Survey
USMC	=	United States Marine Corps
USN	=	United States Navy
VCFCD	=	Ventura County Flood Control District
VISTA	=	Vista Irrigation District
WRCO	=	Warner Resort Company
YCFCD	=	Yavapai County Flood Control District

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Apache	Alpine	33 51 00	109 08 00	8050	X	X											NOAA	NWS4	NONE	0159
Apache	Alpine	33 54 00	109 06 00	8000	X	X		X	X	X						X	USFS	NWS1	NONE	020401
Apache	Arbabs Forest	35 42 00	109 12 00	7680												X	SCS	SCS	METEOR BURST	9P02
Apache	Baldy	33 59 00	109 31 00	9125	X	X										X	SCS	SCS	METEOR BURST	09S01S
Apache	Baldy #2	33 56 00	109 33 00	9750												X	SCS	SCS	METEOR BURST	09S15
Apache	Beaver Spring	36 20 00	109 03 00	9220		X										X	SCS	SCS	METEOR BURST	9N05
Apache	Black Cr blw wf Blk	35 17 05	109 12 54	Unknown		X										X	USGS	USGS	GOES	09395990
Apache	Buck Spring	34 07 00	109 51 00	7400	X	X										X	SCS	SCS	METEOR BURST	09R11S
Apache	Buck Springs nr Pntp	34 06 42	109 50 17	Unknown		X											USGS	USGS	GOES	340642109501701
Apache	Canyon de Chelly	36 09 00	109 32 00	5610	X	X											NOAA	NWS4	NONE	1248
Apache	Cheese Springs	34 03 00	109 30 00	8700												X	SCS	SCS	METEOR BURST	09R07
Apache	Coronado Trail	33 48 00	109 09 00	8350												X	SCS	SCS	METEOR BURST	9S07
Apache	Coronado Trail	33 48 00	109 09 00	8400	X	X										X	SCS	SCS	METEOR BURST	9S07S
Apache	Fluted Rock	35 53 00	109 15 00	7800												X	SCS	SCS	METEOR BURST	09P01
Apache	Fort Apache	34 00 00	109 31 00	9160												X	SCS	SCS	METEOR BURST	09R05
Apache	Ganado	35 43 00	109 34 00	6340	X	X											NOAA	NWS4	NONE	3303
Apache	Greer	34 01 00	109 28 00	8491	X	X										X	NOAA	NWS4	NONE	3683
Apache	Hawley Lake	33 59 00	109 45 00	8180	X	X	X										NOAA	NWS4	NONE	3926
Apache	Klagetoe 12 WNW	35 33 00	109 42 00	6500	X	X											NOAA	NWS4	NONE	4686
Apache	Lukachukai	36 25 00	109 14 00	6520	X	X											NOAA	NWS4	NONE	5129
Apache	Lyman Lk Splwy	34 22 28	109 23 03			X										X	USGS	USGS	GOES	LYMS 162801 68 09384500
Apache	Maverick (RAWS)	34 10 10	109 29 26		X	X		X	X	X		X				X	FTAP	FTAP	GOES	
Apache	Maverick Fork	33 55 00	109 27 00	9150												X	SCS	SCS	METEOR BURST	09S02
Apache	Maverick Fork	33 55 00	109 27 00	9200	X	X										X	SCS	SCS	METEOR BURST	09S02S
Apache	Mc Nary 2 N	34 07 00	109 51 00	7340	X	X										X	NOAA	NWS4	NONE	5412 **
Apache	McNary	34 04 00	109 51 00	7320	X	X											NOAA	NWS4	NONE	5412
Apache	Nutrioso	33 54 00	109 09 00	8500												X	SCS	SCS	METEOR BURST	09S04
Apache	Painted Desert N Prk	35 04 00	109 46 00	5760		X										X	NOAA	NWS4	NONE	6190
Apache	Piney Hill	35 48 00	109 06 00	7958	X	X		X	X	X							BIA	NWS1	NONE	020402
Apache	Puerco River nr Cham	35 10 42	109 27 15			X										X	USGS	USGS	GOES	PURO 162905FA 09396100
Apache	Saint Johns	34 31 00	109 23 00	5790	X	X										X	NOAA	NWS4	NONE	7435
Apache	Sanders	35 13 00	109 20 00	5853	X	X											NOAA	NWS4	NONE	7488
Apache	Springerville	34 08 00	109 17 00	7060	X	X											NOAA	NWS4	NONE	8162
Apache	Sunrise Mountain	33 58 00	109 35 00	9370	X	X											NOAA	NWS4	NONE	8326
Apache	Teec Nos Pos	36 54 00	109 06 00	5290	X	X										X	NOAA	NWS4	NONE	8468
Apache	Tsaile Canyon #1	36 24 00	109 06 00	8160		X										X	SCS	SCS	METEOR BURST	09N02
Apache	Tsaile Canyon #2	36 27 00	109 06 00	8920												X	SCS	SCS	METEOR BURST	09N04

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Cochise	Apache Power Co.	31 54 00	110 15 00	3690	X	X											NOAA	NWS4	NONE	309
Cochise	Benson 6 SE	31 54 00	110 15 00	3690	X	X										X	NOAA	NWS4	NONE	683
Cochise	Bisbee 2 WNW	31 28 00	109 56 00	5600	X	X										X	NOAA	NWS4	NONE	775
Cochise	Bowie	32 20 00	109 20 00	3770	X	X										X	NOAA	NWS4	NONE	958
Cochise	Cascabel	32 19 00	110 24 00	3145	X	X											NOAA	NWS4	NONE	1330
Cochise	Chiricahau Mountain	32 00 00	109 22 00	5480	X	X		X	X	X							NPS	NWS1	NONE	21403
Cochise	Chiricahua N M	32 00 00	109 21 00	5300	X	X											NOAA	NWS4	NONE	1664
Cochise	Cochise 4 SSE	32 04 00	109 54 00	4180		X											NOAA	NWS4	NONE	1870
Cochise	Cochise Stronghold	31 53 00	109 54 00	4920	X	X											NOAA	NWS4	NONE	1874
Cochise	Coronado N Mnt Hdq	31 21 00	110 15 00	5242	X	X											NOAA	NWS4	NONE	2140
Cochise	Coronado Portable #1	32 12 00	110 24 00	3100	X	X		X	X	X							USFS	BLM	NONE	32330464
Cochise	Douglas	31 21 00	109 32 00	4040	X	X										X	NOAA	NWS4	NONE	2659
Cochise	Douglas FAA AP	31 27 00	109 36 00	4100	X	X										X	NOAA	NWS4	NONE	2664
Cochise	Douglas FCWOS	31 28 00	109 36 00	4107	X	X		X	X		X						NWS3	NWS3	NONE	DUG
Cochise	Fairbank	31 42 00	110 12 00	3850		X											SAFD	SAFD	NONE	Unknown
Cochise	Fort Bowie	32 09 00	109 26 00	5020	X	X		X	X	X							NPS	NWS1	NONE	21404
Cochise	Fort Bowie	32 12 00	109 30 00	4800	X	X		X	X	X							BLM	NWS1	NONE	021406
Cochise	Fort Huachuca AAF	31 35 00	110 20 00	4664	X	X		X	X		X						USAF	NWS4	ALERT	3124
Cochise	McNeal	31 36 00	109 34 00	4170		X										X	NOAA	NWS4	NONE	5418 **
Cochise	Monte Vista	31 48 00	109 18 00	9370	X	X		X	X	X							USFS	NWS1	NONE	021401
Cochise	Moson	31 36 00	110 09 00	3980		X											SAFD	SAFD	NONE	
Cochise	Pearce Sunsites	31 56 00	109 48 00	4350	X	X											NOAA	NWS4	NONE	6353
Cochise	Portal	31 54 00	109 12 00	4900	X	X		X	X	X							USFS	NWS1	NONE	021402
Cochise	Portal 4 SW	31 53 00	109 12 00	5390	X	X										X	NOAA	NWS4	NONE	6716
Cochise	Roller Coaster Wash RGage 1	32 18 10	110 00 03	Unknown		X											USGS	USGS	GOES	321810110000301
Cochise	Rucker Canyon	31 45 00	109 25 00	5370		X										X	NOAA	NWS4	NONE	7334
Cochise	San Pedro River nr Pal	31 22 48	110 06 38	Unknown		X										X	USGS	USGS	GOES	PEDP 1629736A 09470500
Cochise	San Simon	32 16 00	109 14 00	3610	X	X										X	NOAA	NWS4	NONE	7560
Cochise	Sierra Vista	31 30 00	110 18 00	4600	X	X		X	X	X							USFS	NWS1	NONE	21405
Cochise	Sierra Vista	31 33 00	110 18 00	4600	X	X										X	NOAA	NWS4	NONE	7880
Cochise	Tombstone	31 42 00	110 03 00	4610	X	X										X	NOAA	NWS4	NONE	8619
Coconino	Ash Fork 5 N	35 17 00	112 28 00	5330	X	X											NOAA	NWS4	NONE	490
Coconino	Ash Fork 6 N	35 18 00	112 29 00	5310	X	X											NOAA	NWS4	NONE	482
Coconino	Ash Fork nr Ash Fork	35 25 00	112 42 30	Unknown		X											USGS	USGS	GOES	352500112423000
Coconino	Baker Butte	34 27 00	111 24 00	7300	X	X										X	SCS	SCS	METEOR BURST	11R06S
Coconino	Baker Butte #2	34 27 00	111 23 00	7700												X	SCS	SCS	METEOR BURST	11R07
Coconino	Bar M	34 51 41	111 36 19	Unknown		X											USGS	USGS	GOES	345141111361900

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Coconino	Bear Seep	34 56 41	111 32 52	Unknown		X											OC & SFCD	OC & SFCD	ALERT	135
Coconino	Bearpaw	35 21 00	111 39 00	10100		X										X	SCS	SCS	METEOR BURST	11P09
Coconino	Big Springs	36 01 48	112 01 48	7300	X	X		X	X	X							USFS	NWS1	NONE	20201
Coconino	Blue Ridge Res Pine	34 33 19	111 11 00	Unknown		X										X	USGS	USGS	GOES	BLRR 1629168C 09398300
Coconino	Blue Ridge RS	34 37 00	111 07 00	6880	X	X										X	NOAA	NWS4	NONE	871
Coconino	Brannigan	35 16 00	111 52 00	8000	X	X		X	X	X						X	USFS	BLM	NONE	323930AC
Coconino	Bright Angel	36 12 00	112 04 00	8000	X	X	X	X	X	X							NPS	NWS1	NONE	020211-FA4520F4
Coconino	Bright Angel	36 13 00	112 04 00	8400												X	SCS	SCS	METEOR BURST	12N01
Coconino	Bright Angel RS	36 12 00	112 04 00	8400	X	X										X	NOAA	NWS4	NONE	1001
Coconino	Buffalo	36 28 15	111 56 45	6800	X	X		X	X	X						X	USFS	BLM	NONE	32391640
Coconino	Cameron 1 NNE	35 53 00	111 24 00	4165	X	X											NOAA	NWS4	NONE	1169
Coconino	Chalender	35 15 00	112 04 00	7100												X	SCS	SCS	METEOR BURST	12P01
Coconino	Chevelon	34 01 48	110 05 24	7010	X	X		X	X	X							USFS	NWS1	NONE	20205
Coconino	Chevelon RS	34 32 00	110 55 00	7006	X	X											NOAA	NWS4	NONE	1574
Coconino	Colo R abv Nat Can	36 15 31	112 53 07	Unknown	X											X	USGS	USGS	GOES	9404120
Coconino	Colorado R abv L Colo	36 12 08	111 48 03	Unknown	X											X	USGS	USGS	GOES	9383100
Coconino	Coyote Park	34 58 36	111 37 58	Unknown		X											OC & SFCD	OC & SFCD	ALERT	(Munds Park)
Coconino	Dry Lake-Park (RAWS)	36 27 00	112 14 15	8900	X	X		X	X	X						X	USFS	NWS1	NONE	020212-32390536
Coconino	Flagstaff	35 08 00	111 40 00	7006	X	X		X	X	X	X	X				X	NWS3	NWS3	NONE	Unknown
Coconino	Flagstaff	35 20 00	111 40 00	7000	X	X		X	X	X							USFS	NWS1	NONE	020209-32339106
Coconino	Flagstaff 4 SW	35 09 00	111 44 00	7125	X	X										X	NOAA	NWS4	NONE	3009
Coconino	Flagstaff WSO AP	35 08 00	111 40 00	7004	X	X										X	NOAA	NWS4	NONE	3010
Coconino	Flagstaff-SAWRS/WSO	35 08 00	111 40 00	7018	X	X		X	X	X	X					X	NWS3	NWS3	NONE	FLG
Coconino	Fort Valley	35 16 00	111 44 00	7347	X	X											NOAA	NWS4	NONE	3160
Coconino	Fort Valley	35 16 00	111 45 00	7350												X	SCS	SCS	METEOR BURST	11P02
Coconino	Fraziers Well	35 05 24	113 00 36	6780	X	X		X	X	X							BIA	NWS1	NONE	20213
Coconino	Fry	35 04 00	111 51 00	7200	X	X										X	SCS	SCS	METEOR BURST	11P13S
Coconino	Gaddes Canyon	34 42 00	112 08 00	7600												X	SCS	SCS	METEOR BURST	12R04
Coconino	Glen Canyon Dam	34 35 00	113 18 00	Unknown	X	X										X	NWS3	NWS3	NONE	324C62BC
Coconino	Glen Canyon Dam	36 56 06	111 29 31	4200	X	X		X	X	X						X	SRP	SRP	ALERT	00
Coconino	Grand Canyon	35 58 00	111 58 00	7500												X	SCS	SCS	METEOR BURST	11P01
Coconino	Grand Canyon AWY	36 03 00	112 08 00	6970	X	X											NOAA	NWS4	NONE	3586
Coconino	Grand Canyon LAWRS	35 57 00	112 09 00	6606	X			X	X	X	X	X					NWS3	NWS3	NONE	GCN
Coconino	Grand Canyon N Park 2	36 03 00	112 09 00	6785	X	X	X									X	NOAA	NWS4	NONE	3596
Coconino	Happy Jack	34 07 00	111 04 00	7480	X	X		X	X	X							USFS	NWS1	NONE	20203
Coconino	Happy Jack	34 45 00	111 24 00	7630												X	SCS	SCS	METEOR BURST	11R05
Coconino	Happy Jack Ranger Station nr	34 44 33	111 24 28	Unknown		X											USGS	USGS	GOES	344433111242801

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Coconino	Pine																			
Coconino	Happy Jack Ranger Stn	34 45 00	111 25 00	7480	X	X											NOAA	NWS4	NONE	3828
Coconino	Jacob Lake	36 44 00	112 13 00	7830	X	X											NOAA	NWS4	NONE	4418
Coconino	JD Cabin nr Williams	35 08 00	112 04 00	Unknown		X											USGS	USGS	GOES	350800112040000
Coconino	Kanab Creek abv Mth	36 23 45	112 37 52	Unknown	X											X	USGS	USGS	GOES	09403850
Coconino	Kelly Pocket	35 04 51	111 41 24	Unknown		X											OC & SFCD	OC & SFCD	ALERT	115
Coconino	Knob Hill	35 02 00	111 06 00	7000	X	X		X	X	X							USFS	NWS1	NONE	20206
Coconino	Lake Mary	35 01 00	111 27 00	6930												X	SCS	SCS	METEOR BURST	11P12
Coconino	Lees Ferry	36 52 00	111 36 00	3210	X	X											NOAA	NWS4	NONE	4849
Coconino	Little Colorado River @ Gran	35 26 00	111 12 00	Unknown		X										X	USGS	USGS	GOES	09401000
Coconino	Little Colorado River nr Cam	35 55 35	111 34 00	Unknown		X										X	USGS	USGS	GOES	09402000
Coconino	Metz Mountain	35 06 52	111 49 14			X											OC&SFCD	OC&SFCD	ALERT	Dutton Hill
Coconino	Mormon Mntn Summit #2	34 58 00	111 31 00	8470												X	SCS	SCS	METEOR BURST	11R12
Coconino	Mormon Mountain	34 56 00	111 31 00	7500	X	X										X	SCS	SCS	METEOR BURST	11R03S
Coconino	Munds Park	34 55 00	111 38 00	6470	X	X										X	NOAA	NWS4	NONE	140
Coconino	Munds Park	34 55 57	111 38 34	6553		X											OC&SFCD	OC&SFCD	ALERT	P/T(Munds Park)
Coconino	Newman park	35 00 00	111 41 00	6750												X	SCS	SCS	METEOR BURST	11P05
Coconino	North Rim (RAWS)	36 03 00	112 09 00	6785	X	X	X	X	X	X							NPS	BLM	METEOR BURST	FA45156E
Coconino	Oak Creek Canyon	34 58 00	111 45 00	5075	X	X										X	NOAA	NWS4	NONE	6037
Coconino	Oak Creek nr Sedona	35 53 13	111 43 49			X										X	USGS	USGS	GOES	Oaks 162A2ACA 09504420
Coconino	Page AMOS/SAWRS	36 56 00	111 27 00	4279	X			X	X			X					NWS3	NWS3	NONE	72371-PGA
Coconino	Phantom Ranch	36 06 00	112 06 00	2569	X	X											NOAA	NWS4	NONE	6471
Coconino	Promontory	34 22 00	111 01 00	7930	X	X										X	SCS	SCS	METEOR BURST	11R10S
Coconino	Pumphouse	35 03 55	111 44 07	5650												X	OC & FSCD	OC & FSCD	ALERT	148
Coconino	Red Hill	35 03 23	111 53 29			X										X	OC & SFCD	OC & SFCD	ALERT	120
Coconino	Rock Gulch nr Rimrock	34 44 49	111 29 38	Unknown		X										X	USGS	USGS	GOES	RCKY 162A39BC 09505220
Coconino	Schnebly Hill	34 53 31	111 38 40	6533													OC & SFCD	OC & SFCD	ALERT	Repeater
Coconino	Sedona Airport															X			ALERT	146
Coconino	Sedona Airport									X									ALERT	151
Coconino	Sedona Airport								X										ALERT	145
Coconino	Sedona Airport							X	X										ALERT	147
Coconino	Sedona Airport				X														ALERT	152
Coconino	Sedona Airport	34 50 38	111 47 35	4737	X	X		X	X	X							OC & SFCD	OC & SFCD	ALERT	150
Coconino	Sedona Ranger Station	34 52 00	111 46 00	4220	X	X											NOAA	NWS4	NONE	7708
Coconino	Small Tank	35 02 54	111 48 12	Unknown		X											OC & SFCD	OC & SFCD	ALERT	125
Coconino	Snow Bowl #1 Alt	35 20 00	111 42 00	9920												X	SCS	SCS	METEOR BURST	11P14
Coconino	Snow Bowl #2	35 20 00	111 42 00	11200												X	SCS	SCS	METEOR BURST	11P06

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Coconino	Snowslide Canyon	35 21 00	111 39 00	9750		X										X	SCS	SCS	METEOR BURST	11P08
Coconino	Sugar Loaf	34 37 00	111 31 00	6120	X	X										X	SCS	SCS	METEOR BURST	11R08S
Coconino	Sunset Crater	35 04 00	111 05 00	6980	X	X		X	X	X							NPS	NWS1	NONE	20208
Coconino	Sunset Crater NM	35 22 00	111 32 00	6980	X	X										X	NOAA	NWS4	NONE	8329
Coconino	Supai	36 12 00	112 42 00	3210	X	X											NOAA	NWS4	NONE	8343
Coconino	Timber Camp	34 07 00	111 02 00	6900	X	X		X	X	X							USFS	NWS1	NONE	20204
Coconino	Tlaquepaque	34 51 42	111 45 40	4169		X											OC & SFCD	OC & SFCD	ALERT	163
Coconino	Tuba City	36 08 00	111 14 00	5030	X	X											NOAA	NWS4	NONE	8792
Coconino	Tusayan (RAWS)	36 24 00	112 09 00	6700	X	X		X	X	X						X	USFS	NWS1	NONE	20207-3233E796
Coconino	Woody Mountain	35 08 02	111 44 34	Unknown		X											OC & SFCD	OC & SFCD	ALERT	110
Coconino	Wupatki	35 05 00	111 05 00	4887	X	X		X	X	X							NPS	NWS1	NONE	20214
Coconino	Wupatki National Monument	35 31 00	111 22 00	4907	X	X										X	NOAA	NWS4	NONE	9542
Coconino	Y Lightening Ranch	31 27 00	110 13 00	4550		X											NOAA	NWS4	NONE	9562
Coconino	Yellow Johns Mountain (RAWS)	36 09 15	113 32 30	6160	X	X		X	X	X		X					BLM	NWS1	NONE	20217-325FB444
GILA	BEER TREE	33 23 00	110 46 00												X		GCES	GCES	ALERT	913
GILA	BEER TREE	33 23 00	110 46 00			x											GCES	GCES	ALERT	910
Gila	Canyon Creek nr Yng	34 17 25	110 48 30	Unknown		X											USGS	USGS	GOES	341725110483001
Gila	Carrizo Creek nr SL	33 59 09	110 16 52	Unknown		X										X	USGS	USGS	GOES	CARZ 1629E608 09496500
Gila	Cherry Cr nr Globe	33 49 40	110 51 20	Unknown		X										X	USGS	USGS	GOES	CHER 1629FBAC 09497980
Gila	Cibeque Crk nr Chry	33 50 35	110 33 25	Unknown		X										X	USGS	USGS	GOES	CIBQ 1629F57E 09497800
Gila	Colcord Mntn nr Pysn	34 18 00	110 57 00	Unknown		X											USGS	USGS	GOES	341800110570000
GILA	COOLIDGE DAM OUTLET	33 11 00	110 31 00												X		GCES	GCES	ALERT	908
GILA	COOLIDGE DAM OUTLET	33 11 00	110 31 00			x											GCES	GCES	ALERT	905
Gila	E Verde R Div f CC	34 25 10	111 15 50	Unknown		X										X	USGS	USGS	GOES	9507580
Gila	East Verde R nr Chi	34 17 00	111 38 50	Unknown		X										X	USGS	USGS	GOES	EVED 162A5C5A 09507980
Gila	Gisela nr Payson	34 06 39	111 16 29	Unknown	X												USGS	USGS	GOES	340639111162901
Gila	Giselda	34 07 00	111 17 00	2900		X											NOAA	NWS4	NONE	3448
Gila	Globe	33 20 00	110 40 00	6700	X	X		X	X	X							USFS	NWS1	NONE	20601-32338270
GILA	GUZMAN CROSSING	33 27 00	110 49 00												X		GCES	GCES	ALERT	918
GILA	GUZMAN CROSSING	33 27 00	110 49 00			x											GCES	GCES	ALERT	915
Gila	Hilltop	33 36 00	110 16 12	6500	X	X		X	X	X							BIA	NWS1	NONE	20606
Gila	Irving	34 24 00	111 37 00	3795		X											NOAA	NWS4	NONE	4391
Gila	Miami	33 24 00	110 53 00	3560	X	X											NOAA	NWS4	NONE	5512
Gila	Payson	34 12 00	111 18 00	5000	X	X		X	X	X							USFS	NWS1	NONE	020602
Gila	Payson	34 14 00	111 20 00	4913	X	X										X	NOAA	NWS4	NONE	6323
Gila	Payson BASIC	34 14 00	111 20 00	4913	X	X		X	X		X	X					NWS3	NWS3	NONE	OE4
Gila	Pleasant Valley	34 06 00	110 54 00	5577	X	X		X	X	X							USFS	NWS1	NONE	020603

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Gila	Pleasant Valley R S	34 06 00	110 56 00	5050	X	X											NOAA	NWS4	NONE	6653
Gila	Pleasant Vlly nr Yng	34 05 53	110 56 27			X											USGS	USGS	GOES	340553110562701
Gila	Punkin Center	33 53 00	111 19 00	2359	X	X										X	NOAA	NWS4	NONE	6840
Gila	Roosevelt	33 24 00	111 04 48	2150	X	X		X	X	X							USFS	NWS1	NONE	20604
Gila	Roosevelt 1 WNW	33 40 00	111 09 00	2205	X	X	X										NOAA	NWS4	NONE	7281
Gila	Salt River nr Chrys	33 47 53	110 29 57			X										X	USGS	USGS	GOES	SLTC 1629E8DA 09497500
Gila	Salt River nr Roosevelt	33 37 10	110 55 15	Unknown		X										X	USGS	USGS	GOES	09498500
Gila	San Carlos	33 21 00	110 27 00	2640	X	X		X	X	X							BIA	NWS1	NONE	20605
GILA	SAN CARLOS LAKE	33 11 00	110 31 00			X											GCES	GCES	ALERT	900
GILA	SAN CARLOS LAKE	33 11 00	110 31 11												X		GCES	GCES	ALERT	903
Gila	San Carlos Reservation @ Coolidge	33 10 32	110 31 38	Unknown		X										X	USGS	USGS	GOES	COOL 16296CE 09469000
Gila	Sierra Ancha	33 48 00	110 58 00	5100	X	X											NOAA	NWS4	NONE	7876
Gila	Snowflake @ Parker Creek	33 47 50	110 57 35	Unknown		X										X	USGS	USGS	GOES	09498503
Gila	Teddy Bear	33 02 00	110 45 00	2160		X											SAFD	SAFD	NONE	Unknown
Gila	Tonto Creek Fish Hatchery	34 23 00	111 06 00	6390		X											NOAA	NWS4	NONE	8650
Gila	Tonto Creek nr Roosevelt	33 58 48	111 18 10	Unknown		X										X	USGS	USGS	GOES	TONT 162A1182 09499000
Gila	Upper Parker Creek	33 47 50	119 57 35	Unknown		X										X	USGS	USGS	GOES	PARK 162A0C26 09498503
Gila	Workman Creek	33 49 00	110 55 00	6900	X	X										X	SCS	SCS	METEOR BURST	10S01S
Graham	Ash Peak	32 43 00	109 13 00	4250		X											SAFD	SAFD	NONE	Unknown
Graham	Black Hills (RAWS)	33 05 12	109 57 02	3350	X	X		X	X	X		X					BLM	NWS1	NONE	021008-372D40DA
Graham	Black R blw Pump	33 28 36	109 45 48	Unknown		X										X	USGS	USGS	GOES	BLKP 1629B8A6 09489500
Graham	Black River Pumps	33 29 00	109 46 00	6040	X	X											NOAA	NWS4	NONE	808
Graham	Bonita	32 27 49	109 55 46	4415	X	X		X	X	X			X	X			AZMET	AZMET	GOES	9
Graham	Bonita Creek nr Morenci	32 57 20	109 31 50	Unknown		X										X	USGS	USGS	GOES	BONM 16294822 09447800
Graham	Columbine	32 48 00	109 54 00	9521	X	X		X	X	X							NPS	NWS1	NONE	21005
Graham	Duncan	32 44 00	109 08 00	3660				X	X								SAFD	SAFD	NONE	Unknown
Graham	Fort Thomas 2 SW	33 01 00	110 00 00	2800	X	X										X	NOAA	NWS4	NONE	3150
Graham	Klondyke	32 48 00	110 21 00	3470		X											SAFD	SAFD	NONE	Unknown
Graham	Limestone-Lower	33 11 00	110 17 00	7000	X	X		X	X	X							BIA	NWS1	NONE	20302
Graham	Muleshoe Ranch (RAWS)	32 24 00	110 40 00	4520	X	X		X	X	X		X					SAFD	SAFD	NONE	021007-3276F0FC
Graham	Oliver Knoll	33 05 00	109 54 00	3850												X	SAFD	SAFD	NONE	
Graham	Oliver Knoll	33 05 00	109 54 00	3850		X											SAFD	SAFD	NONE	
Graham	Pima Plots	32 54 00	110 01 00	3220		X											SAFD	SAFD	NONE	
Graham	Pima Plots	32 54 00	110 01 00	3220	X					X							SAFD	SAFD	NONE	
Graham	Point of Pines	33 22 00	109 45 00	5922	X	X		X	X	X							BIA	NWS1	NONE	021004
Graham	Safford	32 48 48	109 40 42	2955	X	X		X	X	X			X	X			AZMET	AZMET	GOES	4

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Graham	Safford	32 51 00	109 38 00	3176	X	X		X	X	X							BLM	NWS1	NONE	21001
Graham	Safford Ag Cntr	32 49 00	109 41 00	2954	X	X	X						X				NOAA	NWS4	NONE	7390
Graham	Safford BASIC/RAMOS	32 49 00	109 41 00	2954	X		X	X	X		X		X			X	NWS3	NWS3	NONE	E74
Graham	Safford Exp Farm	32 48 00	109 42 00	2954	X	X		X	X	X							BLM	NWS1	NONE	21006
Graham	San Carlos Reservoir	33 10 00	110 31 00	2532	X	X	X										NOAA	NWS4	NONE	7480
Graham	Tanque	32 39 00	109 38 00	3640		X											SAFD	SAFD	NONE	Unknown
Greenlee	Alpine	33 44 00	109 07 00	6730		X										X	NOAA	NWS4	NONE	174
Greenlee	Alpine 18 SW	33 38 00	109 20 00	9160	X	X											NOAA	NWS4	NONE	170
Greenlee	Bearwallow Mountain	33 26 48	108 40 03			X											Clifton	Clifton	ALERT	530
Greenlee	Beaver Head	33 42 00	109 12 00	8000												X	SCS	SCS	METEOR BURST	9S06
Greenlee	Blue	33 35 00	109 10 00	5420	X	X											NOAA	NWS4	NONE	855
Greenlee	Blue River	33 17 00	109 14 00												X		Clifton	Clifton	ALERT	528
Greenlee	Blue River	33 17 00	109 14 00			X									x		Clifton	Clifton	ALERT	525
Greenlee	Blue River nr Clif	33 17 27	109 11 44	Unknown		X										X	USGS	USGS	GOES	BLUC 16292DC4 09444200
GREENLEE	BLUE RIVER REPEATER	33 17 00	109 14 00													x	CLIFTON	CLIFTON	ALERT	526
Greenlee	Blue Vista	33 35 10	109 23 16			X											Clifton	Clifton	ALERT	575
Greenlee	Clifton	33 03 00	109 17 00	3480	X	X										X	NOAA	NWS4	NONE	1849
Greenlee	Clifton	33 03 10	109 17 36												X		Clifton	Clifton	ALERT	563
Greenlee	Clifton	33 03 10	109 17 36			X											Clifton	Clifton	ALERT	560
Greenlee	Duncan	32 45 00	109 07 00	3660	X	X											NOAA	NWS4	NONE	2754
Greenlee	Eagle Cr abv Pump	33 04 18	109 27 10	Unknown		X										X	USGS	USGS	GOES	EGLM 162946F0 09447000
Greenlee	Eagle Creek 2	33 21 00	109 29 00	4870		X											NOAA	NWS4	NONE	2781
Greenlee	Eagle Peak	33 26 25	108 34 57			X											Clifton	Clifton	ALERT	535
Greenlee	Gila River nr Clifton	32 57 55	109 18 25	Unknown		X										X	USGS	USGS	GOES	GICL 162BFE58 09442000
Greenlee	Glenwood Brushy	33 19 05	108 56 29													X	Clifton	Clifton	ALERT	558
Greenlee	Glenwood Brushy	33 19 05	108 56 29			X											Clifton	Clifton	ALERT	554
Greenlee	Glenwood Stream	33 14 53	108 52 47												X		Clifton	Clifton	ALERT	548
Greenlee	Glenwood Stream	33 14 53	108 52 47			X											Clifton	Clifton	ALERT	545
Greenlee	Guthrie (RAWS)	32 57 00	109 17 00	6400	X	X		X	X	X		X					BLM	NWS1	NONE	21104-327D03D0
Greenlee	Guthrie Peak	33 14 53	108 52 47													X	Clifton	Clifton	ALERT	505
Greenlee	Hannagan	33 38 06	109 19 35	Unknown		X											USGS	USGS	GOES	333806109193500
Greenlee	Hannagan Meadow	33 38 00	109 20 00	9300	X	X		X	X	X							USFS	NWS1	NONE	21102
Greenlee	Hannagan Meadows	33 38 00	109 19 00	9090												X	SCS	SCS	METEOR BURST	09S11
Greenlee	Hannagan Meadows	33 39 00	109 19 00	9020	X	X										X	SCS	SCS	METEOR BURST	09S11S
Greenlee	Maverick Hill	33 03 56	109 04 23			X											Clifton	Clifton	ALERT	515
Greenlee	N Fork Thomas Crk	33 40 31	109 16 13			X										X	USGS	USGS	GOES	NFTH 16298674 09489082
Greenlee	Rose Peak	33 24 00	109 18 00	8787	X	X		X	X	X							USFS	NWS1	NONE	21101

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Greenlee	Rose Peak	33 26 25	109 22 11													X	Clifton	Clifton	ALERT	504
Greenlee	Rose Peak	33 26 25	109 22 11			X											Clifton	Clifton	ALERT	500
Greenlee	Saddle Mountain	33 36 21	109 00 30			X											Clifton	Clifton	ALERT	540
Greenlee	San Francisco River @ Clifton	33 02 58	109 17 43	Unknown		X										X	USGS	USGS	GOES	SFCL 16293060 09444500
Greenlee	Sardine Saddle	33 11 40	109 22 45			X											Clifton	Clifton	ALERT	510
Greenlee	Stray Horse	33 19 12	109 11 24	7700	X	X		X	X	X							USFS	NWS1	NONE	21103
Greenlee	Sunflower Mesa	33 13 00	109 14 00												x		Clifton	Clifton	ALERT	523
Greenlee	Sunflower Mesa	33 13 00	109 14 00			X									X		Clifton	Clifton	ALERT	520
GREENLEE	SUNFLOWER MESA REPEATER	33 13 00	109 14 00												x		CLIFTON	CLIFTON	ALERT	521
Greenlee	Tollhouse Canyon	32 50 00	109 16 00	4790		X											SAFD	SAFD	NONE	Unknown
La Paz	Alamo Dam	34 13 06	113 37 04	1265	X	X										X	COE	COE	METEOR BURST	CE475D94
La Paz	Alamo Dam	34 13 43	113 34 40	1240		X											COE	COE	METEOR BURST	Unknown
La Paz	Alamo Dam	34 14 00	113 35 00	1290	X	X										X	NOAA	NWS4	NONE	0100
La Paz	Bill Williams b ALDm	34 13 51	113 36 29	967	X											X	COE	COE	METEOR BURST	CE227058 09426000
La Paz	Bill Williams n Prkr	34 15 45	114 01 37	500												X	COE	COE	METEOR BURST	CE22A630 09426620
La Paz	Bouse	33 57 00	114 02 00	925	X	X										X	NOAA	NWS4	NONE	949
La Paz	Centennial Wsh nr S	33 43 29	113 30 46	Unknown		X										X	USGS	USGS	GOES	CENT 162ABFA8 09517260
La Paz	Ehrenberg 2 E	33 35 00	114 25 00	465	X	X										X	NOAA	NWS4	NONE	2790
La Paz	Quartzsite	33 40 00	114 14 00	875	X	X											NOAA	NWS4	NONE	6865
La Paz	Santa Maria River	34 18 21	113 20 47	Unknown	X	X										X	USGS	USGS	GOES	09424900
La Paz	Smith Peak	34 06 57	113 20 50	2500	X	X		X	X	X							BLM	BLM	METEOR BURST	21501-327D7540
La Paz	Solome 17 SE	33 41 00	113 29 00	1599	X	X										X	NOAA	NWS4	NONE	7462
LaPaz	Parker	33 52 58	114 26 52	307	X	X		X	X	X			X	X			AZMET	AZMET	GOES	08
LaPaz	Parker 6 NE	34 13 00	114 13 00	410	X	X										X	NOAA	NWS4	NONE	6250
Maricopa	48st St. Drain					X										X			ALERT	4525
Maricopa	48th St. Drain														X	X			ALERT	4528
Maricopa	ACDC @ 14th St.														X	X			ALERT	4813
Maricopa	ACDC @ 14th St.					X									X				ALERT	4810
Maricopa	ACDC/43rd Ave	33 24 50	112 09 02			X											MCFCD	NWS6	ALERT NONE	1539
Maricopa	ACDC/43rd Ave	33 35 03	112 09 16	1225												X	MCFCD	NWS6	ALERT	4823
Maricopa	ACDC/43rd Ave	33 35 03	112 09 16	1225		X											MCFCD	NWS6	ALERT	4820
Maricopa	ACDC/67th Ave	33 37 26	112 12 10	1220												X	MCFCD	NWS6	ALERT	5523
Maricopa	ACDC/67th Ave	33 37 26	112 12 10	1220		X											MCFCD	NWS6	ALERT	5520
Maricopa	Adobe Dam	33 40 37	112 09 12	1413		X											MCFCD	NWS6	ALERT	5535
Maricopa	Adobe Dam Outlet	33 40 37	112 09 12	1413												X	MCFCD	NWS6	ALERT	5538
Maricopa	Adobe Dam Pool	33 40 37	112 09 12	1413												X	MCFCD	NWS6	ALERT	5539
Maricopa	Agua Fria @ Buckeye	33 26 05	112 19 54	940		X											MCFCD	NWS6	ALERT	5400

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Maricopa	Agua Fria @ Buckeye	33 26 05	112 19 55	940											X	X	MCFCD	NWS6	ALERT	5403
Maricopa	Agua Fria before Stn	33 36 36	112 09 53	1194		X											MCFDC	MCFDC	ALERT	1150
Maricopa	Agua Fria R @ El M	33 36 24	112 18 14	Unknown		X										X	USGS	USGS	GOES	09513650
Maricopa	Agua Fria R @ EL Mrg	33 26 06	112 19 59	1115												X	COE	COE	METEOR BURST	CE472804 09913650
Maricopa	Agua Fria R Trib Y	33 34 47	112 18 02	Unknown		X										X	USGS	USGS	GOES	09513700
Maricopa	Aguila	33 56 48	113 11 20	2150	X	X		X	X	X			X	X			AZMET	AZMET	GOES	07
Maricopa	Aguila	33 57 00	113 11 00	2165	X	X											NOAA	NWS4	NONE	0060
Maricopa	Ahwatukee Golf Course	33 20 03	111 58 10	1260		X											MCFCD	MCFCD	ALERT	0011
Maricopa	Alameda	33 23 47	111 55 09	1180	X			X	X	X	X	X					SRP	SRP	ALERT	01
Maricopa	Alma School Drain														X	X			ALERT	4538
Maricopa	Alma School Drain					X													ALERT	4535
Maricopa	Alvord Park	33 22 22	112 08 08	1070		X											MCFCD	NWS6	ALERT NONE	4500
Maricopa	Arcadia	33 30 45	112 00 10	1245	X			X	X	X	X	X					SRP	SRP	ALERT	2
Maricopa	Arizona Hunt Club	34 23 26	112 07 42	3805		X											MCFCD	NWS6	ALERT	5775
Maricopa	Asher Hills	33 43 03	111 41 01	1680		X											MCFCD	NWS6	ALERT	5900
Maricopa	Bartlett Dam	32 49 00	111 38 00	1650	X	X	X									X	NOAA	NWS4	NONE	632
Maricopa	Bender Wash	32 54 39	112 31 56	1243		X											MCFCD	NWS6	ALERT	6960
Maricopa	Bloody Basin	34 03 04	111 51 28	4595		X											MCFCD	NWS6	ALERT NONE	2610
Maricopa	Box Canyon	34 02 56	112 42 05	2245												X	MCFCD	NWS6	ALERT	5308
Maricopa	Box Canyon	34 02 56	112 42 05	2245		X											MCFCD	NWS6	ALERT	5305
Maricopa	Buckeye	33 23 00	112 35 00	894	X	X										X	NOAA	NWS4	NONE	1026
Maricopa	Buckeye FRS #1	33 27 31	112 45 02	1097											X	X	MCFCD	NWS6	ALERT	5203
Maricopa	Buckeye FRS #1	33 27 31	112 45 02	1097		X											MCFCD	NWS6	ALERT	5200
Maricopa	Buckeye FRS #2	33 26 26	112 35 47	1150											X				ALERT	5208
Maricopa	Buckeye FRS #2	33 26 26	112 35 47	1150		X													ALERT	5205
Maricopa	Buckeye FRS #3	33 26 49	112 33 20	1200											X				ALERT	6813
Maricopa	Buckeye FRS #3	33 26 49	112 33 20	1200		X													ALERT	6810
Maricopa	Carefree	33 49 00	111 54 00	2530	X	X											NOAA	NWS4	NONE	1282
Maricopa	Carefree Ranch	33 52 03	111 51 00	3200											X				ALERT	4926
Maricopa	Carefree Ranch	33 52 03	111 51 00	3200											X	X	MCFCD	NWS6	ALERT	4934
Maricopa	Carefree Ranch	33 52 03	111 51 00	3200					X										ALERT	4925
Maricopa	Carefree Ranch	33 52 03	111 51 00	3200				X	X								MCFCD	NWS6	ALERT	4927
Maricopa	Carefree Ranch	33 52 03	111 51 00	3200		X											MCFCD	NWS6	ALERT	4930
Maricopa	Carefree Ranch	33 52 03	111 51 00	3200	X												MCFCD	NWS6	ALERT	4933
Maricopa	Carriage Lane Park	33 21 34	111 53 22	1200		X											MCFCD	NWS6	ALERT	6520
Maricopa	Castle Hot Springs	33 55 42	112 31 42	2683		X											MCFCD	NWS6	ALERT	5490
Maricopa	Cave Buttes Dam	33 42 58	112 02 43	1649		X											MCFCD	NWS6	ALERT	4900

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Maricopa	Cave Buttes Outlet	33 42 58	112 02 43	1649											X		MCFCD	NWS6	ALERT	4903
Maricopa	Cave Buttes Pool	33 42 58	112 02 43	1649												X	MCFCD	NWS6	ALERT	4899
Maricopa	Cave Cr blw Cot CC	33 53 14	111 51 12	Unknown		X										X	USGS	USGS	GOES	CAVE 162A7AB6 09512280
Maricopa	Cave Creek	33 49 50	111 57 57	2000											X		MCFCD	NWS6	ALERT	6413
Maricopa	Cave Creek	33 49 50	111 57 57	2000		X											MCFCD	NWS6	ALERT	6410
Maricopa	Cave Creek @ Cactus	33 35 56	112 07 01	1280											X		MCFCD	NWS6	ALERT	4833
Maricopa	Cave Creek @ Cactus	33 35 56	112 07 01	1280		X											MCFCD	NWS6	ALERT	4830
Maricopa	Cave Creek Landfill	33 42 28	111 59 40	1627		X													ALERT	4915
Maricopa	Centennial Levee	33 30 37	113 18 07	1298		X											MCFCD	NWS6	ALERT	5120
Maricopa	Centennial Railroad	33 18 35	112 52 56	850											X		MCFCD	NWS6	ALERT	5103
Maricopa	Centennial Railroad	33 18 35	112 52 56	850		X											MCFCD	NWS6	ALERT	5100
Maricopa	Centennial Wash	33 57 03	113 00 02	2417		X											MCFCD	NWS6	ALERT	5180
Maricopa	Chandler Heights	33 13 00	111 41 00	1425	X	X										X	NOAA	NWS4	NONE	1514
Maricopa	Chrysler Prving Grnds	33 47 04	112 30 03	1720		X											MCFCD	NWS6	ALERT	5460
Maricopa	Circle City	33 49 22	112 35 25	1890		X											MCFCD	NWS6	ALERT	5475
Maricopa	City of Glendale	33 32 45	112 11 43	1148		X											MCFCD	NWS6	ALERT	4770
Maricopa	Collier	33 27 44	112 17 31	1072	X			X	X	X	X	X					SRP	SRP	ALERT	3
Maricopa	Columbia Hill	34 01 04	112 21 09	2393		X											MCFCD	NWS6	ALERT	5685
Maricopa	Cooks Mesa	34 03 34	111 57 06	4565		X											MCFCD	NWS6	ALERT	5640
Maricopa	Corbell	33 21 33	111 49 43	1210	X			X	X	X	X	X					SRP	SRP	ALERT	4
Maricopa	Deer Valley Airport	33 41 06	112 04 59	1445		X											MCFCD	NWS6	ALERT	5550
Maricopa	Deer Valley-Phx LAWRS	33 41 00	112 05 00	1512	X			X	X	X	X						NWS3	NWS3	NONE	DVT
Maricopa	Doggy Jones	33 33 45	112 34 26	2683		X											MCFCD	MCFCD	ALERT	3
Maricopa	Dreamy Draw	33 33 45	112 01 54	1407												X	MCFCD	NWS6	ALERT	4799
Maricopa	Dreamy Draw	33 33 45	112 01 54	1407		X											MCFCD	NWS6	ALERT	4800
Maricopa	Dreamy Draw Dam	33 33 45	112 01 50	1382		X											MCFCD	MCFCD	ALERT	5
Maricopa	Durango Complex	33 25 41	112 07 09	1050												X			ALERT	4696
Maricopa	Durango Complex	33 25 41	112 07 09	1050								X							ALERT	4704
Maricopa	Durango Complex	33 25 41	112 07 09	1050					X										ALERT	4695
Maricopa	Durango Complex	33 25 41	112 07 09	1050				X	X										ALERT	4697
Maricopa	Durango Complex	33 25 41	112 07 09	1050		X													ALERT	4700
Maricopa	Durango Complex	33 25 41	112 07 09	1050	X														ALERT	4702
Maricopa	Dysart @ Bell Rd.	33 38 11	112 20 27	1190		X													ALERT	5510
Maricopa	East Fork Sycamore	33 56 58	111 27 39	Unknown		X										X	USGS	USGS	GOES	09510100
Maricopa	El Mirage Drain														X				ALERT	5603
Maricopa	El Mirage Drain					X													ALERT	5600
Maricopa	EMF @ Arizona Ave.	33 10 53	111 51 50	1214												X	MCFCD	NWS6	ALERT	6594

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Maricopa	EMF @ Arizona Ave.	33 10 53	111 51 50	1214		X											MCFCD	NWS6	ALERT	6595
Maricopa	EMF @ Broadway	33 24 21	111 42 42	1349											X		MCFCD	NWS6	ALERT	6568
Maricopa	EMF @ Broadway	33 24 21	111 42 42	1349		X											MCFCD	NWS6	ALERT	6565
Maricopa	EMF @ Queencreek Rd.	33 15 50	111 43 35	1317											X		MCFCD	NWS6	ALERT	6583
Maricopa	EMF @ Queencreek Rd.	33 15 50	111 43 35	1317		X											MCFCD	NWS6	ALERT	6580
Maricopa	Estrella Fan	33 19 15	112 19 15	1425												X			ALERT	6886
Maricopa	Estrella Fan	33 19 15	112 19 15	1425												X			ALERT	6898
Maricopa	Estrella Fan	33 19 15	112 19 15	1425											X				ALERT	6893
Maricopa	Estrella Fan	33 19 15	112 19 15	1425										X					ALERT	6894
Maricopa	Estrella Fan	33 19 15	112 19 15	1425					X										ALERT	6891
Maricopa	Estrella Fan	33 19 15	112 19 15	1425				X											ALERT	6885
Maricopa	Estrella Fan	33 19 15	112 19 15	1425			X	X											ALERT	6887
Maricopa	Estrella Fan	33 19 15	112 19 15	1425		X													ALERT	6890
Maricopa	Estrella Fan	33 19 15	112 19 15	1425	X														ALERT	6892
Maricopa	Estrella Park	33 23 08	112 22 24	950		X											MCFCD	NWS6	ALERT	6840
Maricopa	Falcon	33 28 09	111 43 56	1365	X		X	X	X	X	X						SRP	SRP	ALERT	5
Maricopa	Fitch Park	33 25 42	111 49 35	1245		X											MCFCD	NWS6	ALERT NONE	4540
Maricopa	Flood Control District	33 25 45	112 07 30	1050		X											MCFCD	NWS6	ALERT NONE	10
Maricopa	Florence Junction	33 17 51	111 23 43	1840		X													ALERT	6730
Maricopa	Fountain	33 36 00	111 42 33	1625	X		X	X	X	X	X						SRP	SRP	ALERT	6
Maricopa	Fountain Hills	33 36 00	111 43 00	1582	X	X										X	NOAA	NWS4	NONE	3190
Maricopa	Fountain Hills	33 37 00	111 33 10	1700		X											MCFCD	MCFCD	ALERT	7
Maricopa	Fraefield Mtn.	33 45 41	111 48 51	2661		X											MCFCD	NWS6	ALERT	5930
Maricopa	Gila @ Estrella Pkwy.	33 23 19	112 23 33	900											X				ALERT	6853
Maricopa	Gila @ St. 85	33 19 55	112 37 26	825											X		MCFCD	NWS6	ALERT	6803
Maricopa	Gila @ St. 85	33 19 55	112 37 26	825		X											MCFCD	NWS6	ALERT	6800
Maricopa	Gila Bend	32 42 23	112 43 33	735		X											MCFCD	MCFCD	ALERT	12
Maricopa	Gila Bend	32 57 00	112 43 00	735	X	X										X	NOAA	NWS4	NONE	3393
Maricopa	Gila Bend AAF	32 57 00	112 43 00	867	X	X	X	X		X							USAF	NWS4	ALERT	3148
Maricopa	Gila Bend Landfill	32 59 20	112 40 29	750		X													ALERT	6910
Maricopa	Gila Bend Mountains	33 22 11	113 18 17	1560										X			MCFCD	NWS6	ALERT	5053
Maricopa	Gila Bend Mountains	33 22 11	113 18 17	1560								X					MCFCD	NWS6	ALERT	5054
Maricopa	Gila Bend Mountains	33 22 11	113 18 17	1560					X								MCFCD	NWS6	ALERT	5051
Maricopa	Gila Bend Mountains	33 22 11	113 18 17	1560				X											ALERT	5045
Maricopa	Gila Bend Mountains	33 22 11	113 18 17	1560			X												ALERT	5046
Maricopa	Gila Bend Mountains	33 22 11	113 18 17	1560			X	X									MCFCD	NWS6	ALERT	5047
Maricopa	Gila Bend Mountains	33 22 11	113 18 17	1560		X											MCFCD	NWS6	ALERT	5050

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Maricopa	Gila Bend Mountains	33 22 11	113 18 17	1560	X												MCFCD	NWS6	ALERT	5052
Maricopa	Gila East West 2	33 22 30	112 26 02	896		X											MCFCD	MCFCD	ALERT	1064
Maricopa	Gila R blw Gillesp	33 13 45	112 46 00	Unknown		X										X	USGS	USGS	GOES	09519500
Maricopa	Gila R blw Painted	33 04 30	113 00 50	Unknown	X											X	USGS	USGS	GOES	09519800
Maricopa	Gila Rvr blw Gillspe Dam	33 13 45	112 46 00	744		X										X	COE	COE	METEOR BURST	CE4788FC 09519501
Maricopa	Gila Rvr Blw Painted Rock	33 04 30	113 00 50	519	X											X	COE	COE	METEOR BURST	CE22939A 09519800
Maricopa	Gladden	33 54 09	112 17 54	2198		X											MCFCD	NWS6	ALERT	5170
Maricopa	Glendale	33 32 33	112 11 48	1140		X											MCFCD	MCFCD	ALERT	1026
Maricopa	Glendale SAWRS	33 38 00	112 36 00	1066	X			X	X		X						NWS3	NWS3	NONE	GEU
Maricopa	Goodyear LAWRS	33 25 00	112 23 00	968	X			X	X	X							NWS3	NWS3	NONE	GYR
Maricopa	Grapevine Wash	33 50 40	111 53 29	1250											X		MCFCD	NWS6	ALERT	6423
Maricopa	Grapevine Wash	33 50 40	111 53 29	1250		X											MCFCD	NWS6	ALERT	6420
Maricopa	Greenway @ 32nd Ave	33 37 31	112 07 45	1300		X											MCFCD	NWS6	ALERT	4840
Maricopa	Griggs 3 W	33 30 00	112 29 00	1160		X											NOAA	NWS4	NONE	3702
Maricopa	Guadalupe FRS	33 22 16	112 58 10	1250											X		MCFCD	NWS6	ALERT	6503
Maricopa	Guadalupe FRS	33 22 16	112 58 10	1250		X											MCFCD	NWS6	ALERT	6500
Maricopa	Harquahala FRS														X				ALERT	5128
Maricopa	Harquahala FRS					X													ALERT	5125
Maricopa	Harquahala Valley	33 26 37	113 10 16	1140		X											MCFCD	MCFCD	ALERT	9
Maricopa	Hassayampa Landfill	33 47 28	111 59 39	1150		X													ALERT	5210
Maricopa	Hassayampa River nr Ar	33 20 50	112 43 30	840		X										X	COE	COE	METEOR BURST	CE47104C 09517000
Maricopa	Hassayampa River nr Ar	33 20 50	112 43 30	Unknown		X										X	USGS	USGS	GOES	09517000
Maricopa	Holly Acres	33 23 12	112 18 08	945		X											MCFCD	NWS6	ALERT	6860
Maricopa	Horsethief Basin	34 06 19	112 20 49	6702												X			ALERT	5696
Maricopa	Horsethief Basin	34 06 19	112 20 49	6702					X										ALERT	5695
Maricopa	Horsethief Basin	34 06 19	112 20 49	6702				X	X								MCFCD	NWS6	ALERT	5697
Maricopa	Horsethief Basin	34 06 19	112 20 49	6702		X											MCFCD	NWS6	ALERT	5700
Maricopa	Horsethief Basin	34 06 19	112 40 49	6702										X			MCFCD	NWS6	ALERT	5703
Maricopa	Horsethief Basin	34 06 19	112 40 49	6702						X							MCFCD	NWS6	ALERT	5701
Maricopa	Horsethief Basin	34 06 19	112 40 49	6702	X												MCFCD	NWS6	ALERT	5702
Maricopa	Horshoe Dam	33 59 00	111 43 00	2020		X										X	NOAA	NWS4	NONE	4182
Maricopa	Humbolt Mtn.	33 58 48	111 47 56	5198		X											MCFCD	NWS6	ALERT	4940
Maricopa	Hydros Climate MCFCD	33 25 40	112 07 27	1047		X											MCFCD	MCFCD	ALERT	1136
Maricopa	IBW @ Indian Bend Rd.	33 32 00	111 54 53	1071											X				ALERT	4613
Maricopa	IBW @ Indian Bend Rd.	33 32 00	111 54 53	1071		X											MCFCD	NWS6	ALERT	4610
Maricopa	IBW @ Interceptor	33 31 57	111 53 55	1071												X	MCFCD	NWS6	ALERT	4619
Maricopa	IBW @ Interceptor	33 31 57	111 53 55	1071		X											MCFCD	NWS6	ALERT	4620

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Maricopa	IBW @ McKellips Rd.	33 26 58	111 54 58	1187											X		MCFCD	NWS6	ALERT NONE	4603
Maricopa	IBW @ McKellips Rd.	33 26 58	111 54 58	1187		X											MCFCD	NWS6	ALERT NONE	4600
Maricopa	IBW @ Sweetwater	33 36 15	112 00 18	1400												X	MCFCD	NWS6	ALERT	4639
Maricopa	IBW @ Sweetwater	33 36 15	112 00 18	1400		X											MCFCD	NWS6	ALERT	4640
Maricopa	Indian Bend Wash 5	33 36 15	111 59 01	1089		X											MCFCD	MCFCD	ALERT	1078
Maricopa	Jackrabbit Wash	33 44 08	112 54 54	1798		X											MCFCD	NWS6	ALERT	5215
Maricopa	Kay	33 25 00	112 09 16	1030	X			X	X	X	X	X					SRP	SRP	ALERT	7
Maricopa	Kings Ranch	33 23 06	111 25 58	2145												X			ALERT	6749
Maricopa	Kings Ranch	33 23 06	111 25 58	2145		X											MCFCD	NWS6	ALERT	6745
Maricopa	Kitchfield Park	33 30 00	112 22 00	1030	X	X										X	NOAA	NWS4	NONE	4877
Maricopa	Kleinman Park	33 24 03	111 51 02	1220		X											MCFCD	NWS6	ALERT NONE	4530
Maricopa	Lake Pleasant	33 50 53	112 16 43	1600												X	NOAA	NWS4	NONE	5646
Maricopa	Lake Pleasant	33 50 53	112 16 43	1600						X							NOAA	NWS4	NONE	5651
Maricopa	Lake Pleasant	33 50 53	112 16 43	1600					X								NOAA	NWS4	NONE	5645
Maricopa	Lake Pleasant	33 50 53	112 16 43	1600				X	D								NOAA	NWS4	NONE	5647
Maricopa	Lake Pleasant	33 50 53	112 16 43	1600			X										NOAA	NWS4	NONE	5665
Maricopa	Lake Pleasant	33 50 53	112 16 43	1600		X											NOAA	NWS4	NONE	5650
Maricopa	Lake Pleasant	33 50 53	112 16 43	1600	X												NOAA	NWS4	NONE	5652
Maricopa	Laveen 3 SSE	33 20 00	112 09 00	1115	X	X										X	NOAA	NWS4	NONE	4829
Maricopa	Leisure World EMF	33 23 30	111 40 42	675		X											MCFCD	MCFCD	ALERT	8
Maricopa	Litchfield	33 28 02	112 23 53	1014	X	X		X	X	X			X	X			AZMET	AZMET	GOES	11
Maricopa	Litchfield Park	33 30 26	112 20 00	690		X											MCFCD	MCFCD	ALERT	10
Maricopa	Lost Dog Wash	33 36 02	111 48 02	1700											X		MCFCD	NWS6	ALERT	4663
Maricopa	Lost Dog Wash	33 36 02	111 48 02	1700		X											MCFCD	NWS6	ALERT	4660
Maricopa	Luke AFB	33 33 00	112 22 00	1101	X	X		X	X		X						USAF	NWS4	ALERT	23111
Maricopa	Magma FRS	33 07 04	111 24 09	1610											X		MCFCD	NWS6	ALERT	6718
Maricopa	Magma FRS	33 07 04	111 24 09	1610		X											MCFCD	NWS6	ALERT	6715
Maricopa	Maricopa	33 04 07	111 58 18	1185	X	X		X	X	X			X	X			AZMET	AZMET	GOES	06
Maricopa	Maryvale Muni Golf	33 28 21	112 09 40	1200		X											MCFCD	NWS6	ALERT	4760
Maricopa	McDowell Mtn. Park	33 43 00	111 44 42	2040		X											MCFCD	NWS6	ALERT	5915
Maricopa	McMicken Dam	33 40 38	112 25 23	1361											X		MCFCD	NWS6	ALERT	5448
Maricopa	McMicken Dam	33 40 38	112 25 23	1361		X											MCFCD	NWS6	ALERT	5445
Maricopa	McMicken Floodway	33 41 04	112 24 33	1337											X		MCFCD	MCFCD	ALERT	5438
Maricopa	McMicken Floodway	33 41 04	112 24 33	1337		X										X	MCFCD	MCFCD	ALERT	5435
Maricopa	Mesa	33 25 00	111 48 00	1235		X										X	NOAA	NWS4	NONE	5467 **
Maricopa	Mesa Experiment Farm	33 25 00	111 52 00	1230	X	X	X										NOAA	NWS4	NONE	5467
Maricopa	Mesa LAWRS	33 28 00	111 44 00	1385				X	X								NWS3	NWS3	NONE	FFZ

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Maricopa	Mesa Tower	33 23 01	111 49 34	1215		X											MCFCD	NWS6	ALERT	6540
Maricopa	Minnehaha	34 10 00	112 22 30	5602		X											MCFCD	NWS6	ALERT	5335
Maricopa	Missouri @ 16th St.	33 31 01	112 02 53	1155		X											MCFCD	NWS6	ALERT	4780
Maricopa	Mormon Flat	33 33 00	111 27 00	1715	X	X										X	NOAA	NWS4	NONE	5700 **
Maricopa	Morristown	33 51 21	112 37 29	1978		X											MCFCD	MCFCD	ALERT	5220
Maricopa	Mountain View Park	33 25 52	111 46 14	1280		X											MCFCD	NWS6	ALERT NONE	4550
Maricopa	Mt. Oatman	33 03 05	113 08 15	1720												X			ALERT	5004
Maricopa	Mt. Oatman	33 03 05	113 08 15	1720		X											MCFCD	NWS6	ALERT	5000
Maricopa	Mt. Ord	33 53 25	111 24 20	7139												X			ALERT	5964
Maricopa	Mt. Ord	33 53 25	111 24 20	7139		X											MCFCD	NWS6	ALERT	5960
Maricopa	New River @ Bell Road	33 38 18	112 14 27	1200		X											MCFCD	NWS6	ALERT	5595
Maricopa	New River @ Glendale	33 32 14	112 17 00	1050											X		MCFCD	NWS6	ALERT	5508
Maricopa	New River @ Glendale	33 32 14	112 17 00	1050		X											MCFCD	NWS6	ALERT	5502
Maricopa	New River Dam	33 44 09	112 13 31	1498		X											MCFCD	NWS6	ALERT	5610
Maricopa	New River Landfill	33 52 20	112 11 40	1508		X													ALERT	5630
Maricopa	New River nr Rck Spr	33 58 27	112 05 54			X										X	USGS	USGS	GOES	NEWR 162AB17A 09513780
Maricopa	New River Outlet	33 44 09	112 13 31	1498											X		MCFCD	NWS6	ALERT	5613
Maricopa	New River Pool	33 44 09	112 13 31	1498											X		MCFCD	NWS6	ALERT	5614
Maricopa	New River/Bell Road	33 38 18	112 14 27	1200											X	X	MCFCD	NWS6	ALERT	5598
Maricopa	NW Regional Landfill	33 39 40	112 29 30	1890		X													ALERT	5465
Maricopa	O'Brien	34 03 48	112 34 20	2798		X											MCFCD	NWS6	ALERT	5320
Maricopa	Old X-cut Canal														X				ALERT	4748
Maricopa	Old X-cut Canal					X													ALERT	4745
Maricopa	Painted Rock Dam	33 04 34	113 01 33	580		X											COE	COE	METEOR BURST	
Maricopa	Painted Rock Dam	33 04 49	113 00 49	1265		X										X	COE	COE	METEOR BURST	CE47660C CE47660C
Maricopa	Painted Rock Dam	33 05 00	113 02 00	550		X											NOAA	NWS4	NONE	6194
Maricopa	Papago Park	33 27 37	111 58 07	1200		X											MCFCD	NWS6	ALERT	4740
Maricopa	Paradise Valley CC	33 32 07	112 00 13	1494		X											MCFCD	NWS6	ALERT	4790
Maricopa	Paradise Valley Park	33 39 17	112 00 13	1494		X											MCFCD	NWS6	ALERT	4650
Maricopa	Pass Mtn. DC														X				ALERT	6633
Maricopa	Pass Mtn. DC					X													ALERT	6630
Maricopa	Patton Rd.	33 43 53	112 34 23	2683		X													ALERT	5450
Maricopa	Pera	33 27 41	111 56 21	1260	X			X	X	X	X	X					SRP	SRP	ALERT	08
Maricopa	Perry Park	33 28 39	112 00 50	1160		X											MCFCD	NWS6	ALERT	4730
Maricopa	Phoenix City	33 27 00	112 04 00	1098	X	X										X	NOAA	NWS4	NONE	6486
Maricopa	Phoenix Encanto	33 28 45	112 05 47	1100	X	X		X	X	X			X	X			AZMET	AZMET	GOES	15
Maricopa	Phoenix Greenway	33 37 17	112 06 30	1315	X	X		X	X	X			X	X			AZMET	AZMET	GOES	12

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Maricopa	Phoenix Municipal	33 27 08	112 04 48	1080	X	X		X	X	X									ALERT	4710
Maricopa	Phoenix WSFO	33 26 00	112 01 00	1107	X	X		X	X	X	X	X				X	NWS3	NWS3	NONE	72278-PHX
Maricopa	Phoenix WSFO AP	33 26 00	112 01 00	1106	X	X										X	NOAA	NWS4	NONE	6481
Maricopa	Pima @ Jomax	33 43 44	111 53 42			X													ALERT	4670
Maricopa	Pima Wash	33 21 54	111 58 42	1338											X		MCFCD	NWS6	ALERT	6533
Maricopa	Pima Wash	33 21 54	111 58 42	1338		X											MCFCD	NWS6	ALERT	6530
Maricopa	Powerline FRS	33 21 06	111 32 34	1580											X				ALERT	6683
Maricopa	Powerline FRS	33 21 06	111 32 34	1580		X													ALERT	6680
Maricopa	Pringle	33 34 14	112 06 29	1230	X			X	X	X	X	X					SRP	SRP	ALERT	9
Maricopa	Queen Creek Landfill	33 13 13	111 38 48	1409		X													ALERT	6615
Maricopa	Queen Creek Rd.	33 15 49	111 37 35	1409		X										X	MCFCD	NWS6	ALERT	6610
Maricopa	Rainbow Valley	33 18 14	112 28 37	940		X											MCFCD	MCFCD	ALERT	1175
Maricopa	Reata Pass Dam	33 44 06	111 50 36	2600											X				ALERT	4938
Maricopa	Reata Pass Dam	33 44 06	111 50 36	2600		X													ALERT	4935
Maricopa	Rittenhouse	33 15 08	111 38 11	1410	X			X	X	X	X	X					SRP	SRP	ALERT	10
Maricopa	Rittenhouse 1	33 16 10	111 23 40	1840		X											MCFCD	NWS6	ALERT	5600
Maricopa	Rittenhouse FRS	33 17 22	111 30 26	1580											X		MCFCD	NWS6	ALERT	6703
Maricopa	Rittenhouse FRS	33 17 22	111 30 26	1580		X											MCFCD	NWS6	ALERT	6700
Maricopa	Roeser @ 2nd St.	33 23 58	112 04 11	1079		X											MCFCD	NWS6	ALERT NONE	4510
Maricopa	Saddleback FRS	33 27 55	113 04 21	1177											X		MCFCD	NWS6	ALERT	5113
Maricopa	Saddleback FRS	33 27 55	113 04 21	1177		X											MCFCD	NWS6	ALERT	5110
Maricopa	Salt River below Stewart Mountain	33 33 10	111 34 33	Unknowwn		X										X	USGS	USGS	GOES	09502000
Maricopa	Salt River Below Stewart Mountain Dam	33 33 10	111 34 33	1370		X										X	COE	COE	METEOR BURST	CE4700E8 09502000
Maricopa	Salt River/24th Street	33 24 57	112 01 43	1100												X	MCFCD	NWS6	ALERT	5903
Maricopa	Salt River/24th Street	33 24 57	112 01 43	1100		X											MCFCD	NWS6	ALERT	5900
Maricopa	Sand Tanks Wash	32 48 06	112 37 55	1108		X											MCFCD	NWS6	ALERT	6940
Maricopa	Sauceda Wash	32 52 27	112 44 57	726											X		MCFCD	NWS6	ALERT	6923
Maricopa	Sauceda Wash	32 52 27	112 44 57	726		X											MCFCD	NWS6	ALERT	6920
Maricopa	Scottsdale LAWRS	33 37 00	111 55 00	1479	X			X	X	X		X					NWS3	NWS3	NONE	SDL
Maricopa	Seven Springs	34 03 06	111 51 17	4595		X													ALERT	4950
Maricopa	Sheely	33 29 17	112 12 43	1070	X			X	X	X	X	X					SRP	SRP	ALERT	12
Maricopa	Signal Buttes FRS	33 26 25	111 35 25	1650											X		MCFCD	NWS6	ALERT	6628
Maricopa	Signal Buttes FRS	33 26 25	111 35 25	1650		X											MCFCD	NWS6	ALERT	6625
Maricopa	Signal Peak	33 17 37	110 50 09													X	GCES	MCFCD	ALERT	6764
Maricopa	Signal Peak	33 17 37	110 50 09			X											GCES	MCFCD	ALERT	6760

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Maricopa	Skunk Creek @ I-17	33 43 37	112 07 03	1471		X											MCFCD	NWS6	ALERT NONE	1155
Maricopa	Skunk Creek @ I-17	33 43 47	112 07 21	1475											X		MCFCD	NWS6	ALERT	5568
Maricopa	Skunk Creek @ I-17	33 43 47	112 07 21	1475		X											MCFCD	NWS6	ALERT	5565
Maricopa	Smith Peak	34 04 00	113 21 03	1097												X			ALERT	5194
Maricopa	Smith Peak	34 04 00	113 21 03	5131		X											MCFCD	NWS6	ALERT	5190
Maricopa	Sols Wash	34 07 25	112 56 55	2771		X											MCFCD	NWS6	ALERT	5275
Maricopa	Sossaman Rd. Drain														X				ALERT	6573
Maricopa	Sossaman Rd. Drain					X													ALERT	6570
Maricopa	South Mountain Park	33 20 46	112 02 59	2135												X			ALERT	6506
Maricopa	South Mountain Park	33 20 46	112 02 59	2135										X			MCFCD	NWS6	ALERT	6513
Maricopa	South Mountain Park	33 20 46	112 02 59	2135								X							ALERT	6514
Maricopa	South Mountain Park	33 20 46	112 02 59	2135						X							MCFCD	NWS6	ALERT	6511
Maricopa	South Mountain Park	33 20 46	112 02 59	2135					X										ALERT	6505
Maricopa	South Mountain Park	33 20 46	112 02 59	2135				X	X								MCFCD	NWS6	ALERT	6507
Maricopa	South Mountain Park	33 20 46	112 02 59	2135		X											MCFCD	NWS6	ALERT	6510
Maricopa	South Mountain Park	33 20 46	112 02 59	2135	X												MCFCD	NWS6	ALERT	6512
Maricopa	South Mountain West	33 19 26	112 09 17	1500		X											MCFCD	NWS6	ALERT	6550
Maricopa	South Phoenix	33 23 00	112 04 00	1155	X	X										X	NOAA	NWS4	NONE	8112
Maricopa	Spookhill FRS	33 28 01	111 40 48	1595											X		MCFCD	NWS6	ALERT NONE	4563
Maricopa	Spookhill FRS	33 28 01	111 40 48	1595		X											MCFCD	NWS6	ALERT NONE	4560
Maricopa	Spurlock	33 21 30	111 27 19	1800	X			X	X	X	X	X					SRP	SRP	ALERT	15
Maricopa	Stapely	33 25 51	111 48 03	1200	X			X	X	X	X	X					SRP	SRP	ALERT	14
Maricopa	Stewart Mountain	33 24 00	111 32 00	1422	X	X										X	NOAA	NWS4	NONE	8214
Maricopa	Stewart Mountain	33 33 46	111 32 10	1440	X		X	X	X	X	X						SRP	SRP	ALERT	13
Maricopa	Sun City 4	33 38 49	112 21 06	1335		X											MCFCD	MCFCD	ALERT	1120
Maricopa	Sun Lakes	33 13 21	111 52 19	1200	X			X	X	X	X	X					SRP	SRP	ALERT	16
Maricopa	Sunflower	33 51 46	111 28 08	Unknown		X											USGS	USGS	GOES	335146111280800
Maricopa	Sunflower 3 NNW	33 54 00	111 29 00	3720		X											NOAA	NWS4	NONE	8273
Maricopa	Sunnycove FRS	33 57 25	112 44 24	2200											X		MCFCD	NWS6	ALERT	5248
Maricopa	Sunnycove FRS	33 57 25	112 44 24	2200		X											MCFCD	NWS6	ALERT	5245
Maricopa	Sunset FRS	33 57 50	112 44 33	2100											X		MCFCD	NWS6	ALERT	5233
Maricopa	Sunset FRS	33 57 50	112 44 33	2100		X											MCFCD	NWS6	ALERT	5230
Maricopa	Sunset Point	34 11 13	112 08 04	3378		X											MCFCD	NWS6	ALERT	5730
Maricopa	Sunup Ranch	33 53 36	112 08 20	2141		X											MCFCD	NWS6	ALERT	5625
Maricopa	Superstition	33 24 58	111 32 03	1750	X			X	X	X	X	X					SRP	SRP	ALERT	
Maricopa	Sycamore Creek nr Fort McDowell	33 41 39	111 32 28	Unknown		X										X	USGS	USGS	GOES	SYCM 162A7464 09510200
Maricopa	Tempe ASU	33 25 00	111 56 00	1170	X	X										X	NOAA	NWS4	NONE	8499

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Maricopa	Thomas @ 16th St.	33 28 37	112 02 27	1120		X											MCFCD	NWS6	ALERT	4720
Maricopa	Thomas Road @ 48th St.	33 28 49	111 58 46	1200		X											MCFCD	NWS6	ALERT	4750
Maricopa	Thompson Peak	33 38 40	111 49 11	3993		X											MCFCD	NWS6	ALERT	5945
Maricopa	Thompson Peak	33 38 40	112 06 50	3993												X	MCFCD	NWS6	ALERT	5949
Maricopa	Thumb Butte Tank	34 32 34	112 30 43	6075		X											YCFCD		ALERT	340
Maricopa	Thunder Mtn.	33 29 48	111 38 25	2552		X											MCFCD	NWS6	ALERT	6655
Maricopa	Thunderbird Academy	33 36 38	111 55 22	1448		X											MCFCD	NWS6	ALERT	4630
Maricopa	Tolleson 1 E	33 27 00	112 14 00	1025		X										X	NOAA	NWS4	NONE	8598
Maricopa	Tonopah	33 28 00	112 57 00	1110	X	X										X	NOAA	NWS4	NONE	8641
Maricopa	Towers Mtn.	34 14 24	112 21 47	7528												X			ALERT	5344
Maricopa	Towers Mtn.	34 14 24	112 21 47	7528		X													ALERT	5340
Maricopa	Upper Skunk Creek	33 53 35	112 04 05	2109		X											MCFCD	NWS6	ALERT	5580
Maricopa	Upper Tiger Wash	33 48 40	113 10 25	2198		X											MCFCD	NWS6	ALERT	5130
Maricopa	Upper Waterman Wash	33 05 25	112 25 25	1600		X											MCFCD	NWS6	ALERT	6900
Maricopa	Usery Mountain	33 29 38	111 36 23	2992		X											MCFCD	NWS6	ALERT	5620
Maricopa	Usery Mtn. Park	33 27 56	111 36 26	1799		X													ALERT	6640
Maricopa	Vekol Wash	32 50 30	112 14 58	1720											X				ALERT	6983
Maricopa	Vekol Wash	32 50 30	112 14 58	1720		X													ALERT	6980
Maricopa	Vineyard FRS	33 21 06	111 32 34	1582											X				ALERT	6688
Maricopa	Vineyard FRS	33 21 06	111 32 34	1582		X													ALERT	6685
Maricopa	Vulture Mine	33 56 42	112 46 07	2311		X													ALERT	5260
Maricopa	Waterman Wash	33 13 15	112 18 31	1263		X													ALERT	6880
Maricopa	White Spar Camp	34 30 22	112 28 39	5608		X											Yavapai Co	Yavapai Co	ALERT	325
Maricopa	White Tanks 3	33 32 01	112 28 14	1190											X				ALERT	5418
Maricopa	White Tanks 3	33 32 01	112 28 14	1190		X													ALERT	5415
Maricopa	White Tanks 4	33 27 04	112 29 40	1044											X				ALERT	6823
Maricopa	White Tanks 4	33 27 04	112 29 40	1044		X													ALERT	6820
Maricopa	White Tanks E. Peak	33 34 08	112 33 29	4031												X			ALERT	5434
Maricopa	White Tanks E. Peak	33 34 08	112 33 29	4931		X													ALERT	5434
Maricopa	Wittmann	33 46 15	112 31 14	1653		X													ALERT	5455
Maricopa	Youngtown	33 36 00	112 18 00	1135	X	X										X	NOAA	NWS4	NONE	9634
Mohave	Arizona Strp Prt(RAWS)	36 34 48	113 31 48	2365	X	X		X	X	X		X					BLM	NWS1	NONE	020112-327C4220
Mohave	Beaver Dam	36 54 00	113 56 00	1875	X	X											NOAA	NWS4	NONE	672
Mohave	Big Sandy River nr W	34 27 35	113 37 25	Unknown		X										X	USGS	USGS	GOES	162AC7EA 09424450
Mohave	Black Rock	36 03 00	113 03 00	6457	X	X		X	x	X		X					BLM	NWS1	NONE	020106
Mohave	Bullhead City	35 10 00	114 34 00	540	X	X										X	NOAA	NWS4	NONE	1050
Mohave	Bullhead City SAWRS	35 10 00	114 34 00	539	X			X	X		X						NWS3	NWS3	NONE	P96

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Mohave	Burro Cr @ Old US 93B	34 32 30	113 26 40	Unknown	X	X										X	USGS	USGS	GOES	09424447
Mohave	Burro Creek nr Bgdad	34 32 30	113 26 40	1880	X	X										X	COE	COE	METEOR BURST	CE1367A4 09424447
Mohave	Colo R abv Diamond	35 46 41	113 20 44	Unknown	X											X	USGS	USGS	GOES	9404200
Mohave	Colorado City	37 00 00	112 59 00	5009	X	X											NOAA	NWS4	NONE	1920
Mohave	Haulpai	35 01 00	113 09 00	6500	X	X		X	X	X							BLM	NWS1	NONE	20101
Mohave	Hibernia (RAWS)	34 54 50	113 52 28	5163	X	X		X	X	X		X					BLM	NWS1	NONE	20110-327D364A
Mohave	Kingman	35 01 12	114 00 00	3540	X	X		X	X	X							BLM	NWS1	NONE	20105
Mohave	Kingman 2	35 12 00	114 01 00	3539	X	X										X	NOAA	NWS4	NONE	4645
Mohave	Kingman AMOS	36 16 00	113 57 00	3389	X			X		X							NWS3	NWS3	NONE	72370-1GM
Mohave	Kingman SAWRS	35 15 00	113 56 00	3446				X	X		X						NWS3	NWS3	NONE	1GM
Mohave	Lake Havasu	34 27 00	114 22 00	482	X	x										X	NOAA	NWS4	NONE	4759
Mohave	Lake Havasu C SAWRS	34 27 00	114 22 00	482	X			X	X								NWS3	NWS3	NONE	LHU
Mohave	Logan (RAWS)	36 22 00	113 11 00	7220	X	X		X	X	X							BLM	NWS1	NONE	20107-324CA7A2
Mohave	Lookout Wash	35 11 59	113 21 47	5060	X	X											COE	COE	METEOR BURST	CE477878
Mohave	Lookout Wash	35 11 59	113 21 47	Unknown		X											USGS	USGS	GOES	351159113214700
Mohave	Mount Trumbull	36 04 00	113 02 00	6500	X	X		X	X	X		X					BLM	NWS1	NONE	020104
Mohave	Olaf Knolls (RAWS)	36 30 00	113 49 00	2900	X	X		X	X	X		X					BLM	NWS1	NONE	020108-324C814E
Mohave	Pakoon	36 05 00	114 00 00	4400	X	X		X	X	X							BLM	NWS1	NONE	020102
Mohave	Peach Springs	35 33 00	113 24 00	4970		X											NOAA	NWS4	NONE	6328
Mohave	Pipe Springs N M	36 52 00	112 44 00	4919	X	X										X	NOAA	NWS4	NONE	6616
Mohave	Radar Hill	35 02 00	114 01 00	3760	X	X		X	X	X							BLM	NWS1	NONE	20103
Mohave	Robinson Tank (RAWS)	36 28 14	112 50 29	5560	X	X		X	X	X		X					BLM	NWS1	NONE	20111-327C27C6
Mohave	Temple Bar Ranger Station	36 10 00	114 19 00	1280	X	X										X	NOAA	NWS4	NONE	8516
Mohave	Truxton Canyon	35 23 00	113 40 00	3820		X											NOAA	NWS4	NONE	8778
Mohave	Tuweep	36 17 00	113 04 00	4780		X											NOAA	NWS4	NONE	8895
Mohave	Tweeds Point	36 35 00	113 43 00	5200	X	X		X	X	X		X					BLM	NWS1	NONE	20109-324C9238
Mohave	Yucca 1 NNE	34 53 00	114 08 00	1950	X	X										X	NOAA	NWS4	NONE	9645
Navajo	Betakin	36 41 00	110 32 00	7286	X	X										X	NOAA	NWS4	NONE	750
Navajo	Chevelon n Winslow	34 38 11	110 42 49	Unknown		X										X	USGS	USGS	GOES	CHEV 16290B28 09397500
Navajo	Cibecue	34 03 00	110 29 00	5050	X	X											NOAA	NWS4	NONE	1749
Navajo	Clay Springs	34 23 00	110 19 00	6320	X	X											NOAA	NWS4	NONE	1760
Navajo	Forest Dale Alt.	34 13 00	110 05 00	6580												X	SCS	SCS	METEOR BURST	10R10
Navajo	Forrestdale Creek	34 10 40	110 00 56	Unknown		X										X	USGS	USGS	GOES	FORD 1629DD40 09495000
Navajo	Heber Ranger Station	34 24 00	110 33 00	6590	X	X										X	NOAA	NWS4	NONE	3961
Navajo	Herber	34 19 00	110 45 00	7640	X	X										X	SCS	SCS	METEOR BURST	10R04S
Navajo	Herber	34 24 00	110 36 00	6600	X	X		X	X	X							USFS	NWS1	NONE	20301
Navajo	Holbrook	34 54 00	110 10 00	5070	X	X											NOAA	NWS4	NONE	4089

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Navajo	Keams Canyon	35 49 00	110 12 00	6205	X	X											NOAA	NWS4	NONE	4586
Navajo	Lakeside	34 16 00	109 58 48	7000	X	X		X	X	X							USFS	NWS1	NONE	20303-32341526
Navajo	Limestone CN (RAWS)	34 10 34	110 10 24	6800	X	X		X	X	X		X				X	BIA	BLM	METEOR BURST	5110020C
Navajo	Little Colorado River @ Wood	34 46 58	110 02 37	Unknown		X										X	USGS	USGS	GOES	LCRW 1628F956 09394500
Navajo	Little Colorado River nr Jos	34 54 04	110 15 17	Unknown		X										X	USGS	USGS	GOES	09397300
Navajo	Ltl Colo R n Jsph Cty	34 54 04	110 15 17	5031		X										X	COE	COE	METEOR BURST	CE47680E 09397300
Navajo	Monument Valley	36 59 00	110 06 00	5564	X	X											NOAA	NWS4	NONE	5665
Navajo	Navajo NM	36 42 00	110 30 00	7286	X	X		X	X	X							NPS	NWS1	NONE	020305
Navajo	Peabody Coal #01	36 24 52	110 24 40	6407	X	X		X	X								PCC	PCC	ALERT	01
Navajo	Peabody Coal #05	36 26 43	110 23 35	6507		X											PCC	PCC	ALERT	05
Navajo	Peabody Coal #07	36 32 32	110 23 00	6746		X											PCC	PCC	ALERT	07
Navajo	Peabody Coal #08	36 31 36	110 18 57	7040	X	X		X	X								PCC	PCC	ALERT	08
Navajo	Peabody Coal #09	36 30 17	110 24 54	6608	X	X		X	X		X	X		X			PCC	PCC	ALERT	09
Navajo	Peabody Coal #10	36 32 48	110 25 19	6761		X											PCC	PCC	ALERT	10
Navajo	Peabody Coal #11	36 28 06	110 16 31	6866		X											PCC	PCC	ALERT	11
Navajo	Peabody Coal #12	36 25 52	110 19 03	6866	X	X		X	X								PCC	PCC	ALERT	12
Navajo	Petrified Frst N Prk	34 49 00	109 53 00	5446	X	X										X	NOAA	NWS4	NONE	6468
Navajo	Pinetop	34 07 00	109 56 00	6960	X	X										X	NOAA	NWS4	NONE	6597
Navajo	Pinetop Fish Hatchery	34 07 00	109 55 00	7200		X										X	NOAA	NWS4	NONE	6601
Navajo	Show Low Airport	34 15 00	110 00 00	6411	X	X											NOAA	NWS4	NONE	7849
Navajo	Show Low BASIC	34 15 00	110 02 00	6411	X			X	X		X	X				X	NWS3	NWS3	NONE	SOW
Navajo	Show Low Lake nr Lake	34 01 47	110 00 13	Unknown												X	USGS	USGS	GOES	SHLK 1628E4F2 09391000
Navajo	Snowflake	34 30 00	110 05 00	5642	X	X										X	NOAA	NWS4	NONE	8012
Navajo	Snowflake 15 W	34 30 00	110 20 00	6080	X	X										X	NOAA	NWS4	NONE	8018
Pima	AC/Houghton	32 15 37	110 45 17	2635											X		Pima Co FCD	Pima Co FCD	ALERT	2199
Pima	AC/Houghton	32 15 37	110 45 17	2635		X											Pima Co FCD	Pima Co FCD	ALERT	2200
Pima	Ajo	32 22 00	112 52 00	1800	X	X										X	NOAA	NWS4	NONE	0080
Pima	Alamo Tank	32 17 30	110 38 00	4100		X											Pima Co FCD	NWS6	ALERT	2080
Pima	Alamo Wash	32 15 32	110 52 59	2440											X		Pima Co FCD	Pima Co FCD	ALERT	2369
Pima	Alamo Wash	32 15 32	110 52 59	2440		X											Pima Co FCD	Pima Co FCD	ALERT	2370
Pima	Alamo Wash	32 15 32	110 52 59	2440		X										X	PCFCD	NWS6	ALERT	3310
Pima	Alamo Wash RGage 01	32 15 15	110 53 16	Unknown		X											USGS	USGS	GOES	321515110531601
Pima	Alamo Wash RGage 02	32 14 52	110 52 44	Unknown		X											USGS	USGS	GOES	321452110524401
Pima	Alamo Wash RGage 04	32 14 21	110 52 47	Unknown		X											USGS	USGS	GOES	321421110524701
Pima	Alamo Wash RGage 05	32 13 21	110 48 47	Unknown		X											USGS	USGS	GOES	321321110484701
Pima	Alamo Wash RGage 06	32 13 49	110 51 06	Unknown		X											USGS	USGS	GOES	321349110510601
Pima	Alamo Wash RGage 07	32 13 31	110 50 53	Unknown		X											USGS	USGS	GOES	321331110515301

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Pima	Alamo Wash RGage 08	32 13 34	110 52 45	Unknown		X											USGS	USGS	GOES	321334110524501
Pima	Alamo Wash RGage 09	32 13 07	110 51 05	Unknown		X											USGS	USGS	GOES	321307110510501
Pima	Alamo Wash RGage 10	32 12 34	110 50 56	Unknown		X											USGS	USGS	GOES	321234110505601
Pima	Alamo Wash RGage 11	32 11 52	110 50 56	Unknown		X											USGS	USGS	GOES	321152110505602
Pima	Alamo Wash RGage 12	32 11 28	110 50 23	Unknown		X											USGS	USGS	GOES	321128110502301
Pima	Alamo Wash RGage 13	32 12 52	110 52 42	Unknown		X											USGS	USGS	GOES	321252110524201
Pima	Alamo Wash RGage 14	32 15 18	110 51 57	Unknown		X											USGS	USGS	GOES	321518110515701
Pima	Alamo Wash RGage No11	32 11 52	110 50 56	Unknown		X											USGS	USGS	GOES	321152110505601
Pima	Anamax	31 52 44	111 03 26	3445		X											Pima Co FCD	NWS6	ALERT	6330
Pima	Anvil Ranch	31 59 00	111 23 00	2750	X	X										X	NOAA	NWS4	NONE	287
Pima	Arivaca 1 E	31 35 00	111 19 00	3680		X										X	NOAA	NWS4	NONE	380
Pima	Avra Valley Airport	32 24 13	111 13 01	2021		X											PCFCD	NWS6	ALERT	6110
Pima	Bellota Ranch Road	32 18 37	110 36 20	4300		X											Pima Co FCD	NWS6	ALERT	2050
Pima	Berverly Well C-51	32 14 01	110 52 44	2522		X											Pima Co FCD	Pima Co FCD	ALERT	2320
Pima	Cargodera	32 26 27	110 50 57	4795	X	X		X	X	X							USFS	BLM	NONE	3238F748
Pima	Cargodera Canyon	32 26 53	110 52 38	3195		X											Pima Co FCD	NWS6	ALERT	1070
Pima	Caterpillar	31 50 26	111 09 39	4165		X											Pima Co FCD	NWS6	ALERT	6320
Pima	CDO at Ina	32 20 07	111 02 32	2245		X											Pima Co FCD	Pima Co FCD	ALERT	1200
Pima	CDO at INA	32 30 07	111 02 32	2245												X	Pima Co FCD	Pima Co FCD	ALERT	1203
Pima	Cemetery Wash RGage 1	32 15 49	110 58 24	Unknown		X											USGS	USGS	GOES	321549110582401
Pima	Cemetery Wash RGage 2	32 15 30	110 57 16	Unknown		X											USGS	USGS	GOES	321530110571601
Pima	Cemetery Wash RGage 3	32 15 07	110 57 53	Unknown		X											USGS	USGS	GOES	321507110575301
Pima	Chiva Tank	32 16 15	110 36 25	3770											X		Pima Co FCD		ALERT	2073
Pima	Chiva Tank	32 16 15	110 36 25	3770		X										X	Pima Co FCD	NWS6	ALERT	2070
Pima	Cholla Wash RGage 1	32 12 06	111 00 38	Unknown		X											USGS	USGS	GOES	321206111003801
Pima	Cholla Wash RGage 2	32 12 05	111 01 24	Unknown		X											USGS	USGS	GOES	321205111012401
Pima	Cholla Wash RGage 3	32 11 57	110 59 53	Unknown		X											USGS	USGS	GOES	321157110595301
Pima	Cholla Wash RGage 4	32 12 27	111 00 26	Unknown		X											USGS	USGS	GOES	321227111002601
Pima	Cholla Wash RGage 5	32 11 53	111 01 57	Unknown		X											USGS	USGS	GOES	321153111015701
Pima	Cienega Creek @ I-10	31 59 09	110 34 02	3570		X										X	Pima Co FCD	NWS6	ALERT	4280
Pima	Cienega/I-10	31 59 09	110 34 02	3570											X		Pima Co FCD	Pima Co FCD	ALERT	4283
Pima	Cocona de Tucson	31 58 12	110 47 42	3147		X											Pima Co FCD	NWS6	ALERT	6290
Pima	Cortaro Road	32 21 04	110 05 39	2145											X		Pima Co FCD		ALERT	6019
Pima	Cortaro Road Bridge	32 21 04	111 05 39	2145		X										X	Pima Co FCD	NWS6	ALERT	6020
Pima	Craycroft Wsh	32 18 20	110 52 13	Unknown	X												USGS	USGS	GOES	321820110521301
Pima	Davidson Canyon	31 59 36	110 38 39	3480											X		Pima Co FCD		ALERT	4313
Pima	Davidson Canyon	31 59 36	110 38 39	3480		X										X	Pima Co FCD	NWS6	ALERT	4310

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Pima	Davis Mountain AFB	32 10 00	110 53 00	2705	X	X		X	X		X						USAF	NWS4	ALERT	23109
Pima	Diamond Bell Ranch	31 59 23	111 17 50	3250		X											Pima Co FCD	NWS6	ALERT	6410
Pima	Dodge Boulevard	32 16 17	110 54 50	2375											X		Pima Co FCD	Pima Co FCD	ALERT	2349
Pima	Dodge Boulevard	32 16 17	110 54 50	2375		X											Pima Co FCD	Pima Co FCD	ALERT	2350
Pima	Dodge Boulevard	32 18 17	110 54 50	2375		X										X	PCFCD	NWS6	ALERT	3050
Pima	Dodge Tank	32 30 47	110 51 51	3240											X		Pima Co FCD		ALERT	1039
Pima	Dodge Tank	32 30 47	110 51 51	3240		X										X	Pima Co FCD	NWS6	ALERT	1040
Pima	Dutch (Muleshoe RAWS)	32 24 00	110 40 00	4520	X	X		X	X	X		X					BLM	NWS1	NONE	021007-3276F0FC
Pima	Empire	31 46 50	110 38 05	4650	X	X		X	X	X		X					BLM	NWS1	NONE	021205-327C5156
Pima	Empire Mountain	31 53 05	110 38 13	5588		X											Pima Co FCD	NWS6	ALERT	4320
Pima	Fish Creek N Globe	32 29 00	111 15 30	Unknown		X											USGS	USGS	GOES	322900111153000
Pima	Gibbons Springs	32 18 14	110 46 20	2805		X											Pima Co FCD	Pima Co FCD	ALERT	2180
Pima	Golder Road Bridge	32 28 40	110 53 58	2960											X		Pima Co FCD		ALERT	1099
Pima	Golder Road Bridge	32 28 40	110 53 58	2960		X										X	Pima Co FCD	NWS6	ALERT	1100
Pima	Green Valley	31 54 00	110 59 00	2850		X										X	NOAA	NWS4	NONE	3668
Pima	Happy Valley	32 12 00	110 30 00	7348	X	X		X	X	X							NPS	NWS1	NONE	21203
Pima	Haystack Mountain	31 54 20	110 27 02	4955		X											Pima Co FCD	Pima Co FCD	ALERT	4410
Pima	Italian Trap	32 16 56	110 33 55	4000		X											Pima Co FCD	NWS6	ALERT	2030
Pima	Keystone Peak	31 52 37	111 12 57	6206		X											Pima Co FCD	NWS6	ALERT	6310
Pima	Kitt Peak	31 58 00	111 36 00	6800	X	X										X	NOAA	NWS4	NONE	4675
Pima	Manning Camp	32 12 00	110 30 00	8000	X	X		X		X							NPS	NPS	GOES	021204
Pima	Manning Camp	32 12 25	110 33 15	7930	X	X											Pima Co FCD	NWS6	ALERT	4100
Pima	Mannings Camp	32 12 25	110 33 15	7930					X								Pima Co FCD	Pima Co FCD	ALERT	4095
Pima	Mannings Camp	32 12 25	110 33 15	7930					X								Pima Co FCD	Pima Co FCD	ALERT	4097
Pima	Mannings Camp	32 12 25	110 33 15	7930				X									Pima Co FCD	Pima Co FCD	ALERT	4096
Pima	Mannings Camp	32 12 25	110 47 20	7930												X	Pima Co FCD	Pima Co FCD	ALERT	4103
Pima	Mannings Camp	32 12 25	110 47 20	7930												X	Pima Co FCD	Pima Co FCD	ALERT	4104
Pima	Mannings Camp	32 12 25	110 47 20	7930						X							Pima Co FCD	Pima Co FCD	ALERT	4101
Pima	Mannings Camp	32 12 25	110 47 20	7930	X												Pima Co FCD	Pima Co FCD	ALERT	4102
Pima	Marana	32 27 40	111 14 00	1973	X	X		X	X				X	X			AZMET	AZMET	GOES	13
Pima	Mescal	31 59 07	110 28 51	3985		X											Pima Co FCD	Pima Co FCD	ALERT	4290
Pima	Mile Wide	32 14 54	111 14 35	2210		X											Pima Co FCD	Pima Co FCD	ALERT	6440
Pima	Mount Lemmon	32 26 26	110 47 15	9000												"2"	Pima Co FCD	Pima Co FCD	ALERT	1093
Pima	Mount Lemmon	32 26 26	110 47 15	9000					X								Pima Co FCD	NWS6	ALERT	1090
Pima	Mount Lemmon	32 26 26	110 47 15	9000				X									Pima Co FCD	Pima Co FCD	ALERT	1086
Pima	Mount Lemmon	32 27 00	110 45 00	7790	X	X											NOAA	NWS4	NONE	5733
Pima	Mt. Lemmon	32 26 26	110 47 15	9000								X					Pima Co FCD		ALERT	1094

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Pima	Mt. Lemmon	32 26 26	110 47 15	9000						X									ALERT	1091
Pima	Mt. Lemmon	32 26 26	110 47 15	9000				X	X								Pima Co FCD		ALERT	1087
Pima	Mt. Lemmon	32 26 26	110 47 15	9000	X												Pima Co FCD		ALERT	1092
Pima	Mt. Lemmon	32 26 28	110 47 15	9155												X			ALERT	1086
Pima	Mt. Lemmon	32 26 28	110 47 15	9155	X	X			X								PCFCD	NWS6	ALERT	1085
Pima	Mule Deer Tank	32 14 49	110 36 40	4500		X											Pima Co FCD	NWS6	ALERT	2060
Pima	N Lazy H Ranch	32 07 00	110 41 00	3050		X										X	NOAA	NWS4	NONE	5908 **
Pima	Organ Pipe Cactus NM	31 56 00	112 47 00	1677	X	X										X	NOAA	NWS4	NONE	6132
Pima	Organ Pipe RGage	31 56 00	112 56 00		X												USGS	USGS	GOES	315600112470001
Pima	Palisades	32 24 00	110 42 00	7950	X	X		X	X	X							USFS	NWS1	NONE	021201
Pima	Pantano Wash nr Vail	32 02 09	110 40 37			X										X	USGS	USGS	GOES	PANT 1629A502 09484600
Pima	Pantano/Houghton	32 10 02	110 46 19	2767		X											Pima Co FCD	Pima Co FCD	ALERT	4180
Pima	Pantano/Vail	32 02 10	110 40 32	3210											X		Pima Co FCD	Pima Co FCD	ALERT	4249
Pima	Pantano/Vail	32 02 10	110 40 32	3210		X											Pima Co FCD	Pima Co FCD	ALERT	4250
Pima	Park Tank	32 15 48	110 32 48	5100		X											Pima Co FCD	NWS6	ALERT	2020
Pima	Queens Well	32 16 18	111 37 59	2030		X											COE	COE	METEOR BURST	Unknown
Pima	R/G #1 nr Lukeville	32 00 29	112 58 43	Unknown		X											USGS	USGS	GOES	320029112584301
Pima	R/G #2 nr Lukeville	31 57 09	113 00 43	Unknown		X											USGS	USGS	GOES	315709113004301
Pima	Rancho Del Lago	32 04 10	110 43 51	3145		X											Pima Co FCD	Pima Co FCD	ALERT	4220
Pima	Redington	32 26 00	110 29 00	2870		X											NOAA	NWS4	NONE	7036
Pima	Rincon Creek	32 07 46	110 37 30	3137											X		Pima Co FCD	Pima Co FCD	ALERT	4109
Pima	Rincon Creek	32 07 46	110 37 30	3137		X										X	Pima Co FCD	NWS6	ALERT	4110
Pima	Rincon Creek nr Tucson	32 07 46	110 37 32	Unknown		X										X	USGS	USGS	GOES	RINC 1629ABDO 09485000
Pima	Rob Wash RGage 1	32 13 50	110 48 54	Unknown		X											USGS	USGS	GOES	321350110485401
Pima	Rob Wash RGage 2	32 12 44	110 48 19	Unknown		X											USGS	USGS	GOES	321244110481901
Pima	Rob Wash RGage 3	32 12 29	110 47 43	Unknown		X											USGS	USGS	GOES	321229110474301
Pima	Rob Wash RGage 4	32 11 57	110 47 05	Unknown		X											USGS	USGS	GOES	321157110470501
Pima	Rob Wash RGage 5	32 13 21	110 48 48	Unknown		X											USGS	USGS	GOES	321321110484801
Pima	Roller Coaster Wash RGage 2	32 18 48	110 59 29	Unknown		X											USGS	USGS	GOES	321848110592901
Pima	Roller Coaster Wash RGage 3	32 18 33	110 58 46	Unknown		X											USGS	USGS	GOES	321833110584601
Pima	Roller Coaster Wash RGage 4	32 19 31	110 58 35	Unknown		X											USGS	USGS	GOES	321931110583501
Pima	Roller Coaster Wash RGage 5	32 20 00	110 58 15	Unknown		X											USGS	USGS	GOES	322000110581501
Pima	Sabino Canyon	32 18 00	110 49 00	2640	X	X											NOAA	NWS4	NONE	7355
Pima	Sabino Canyon Dam	32 18 54	110 48 36	2160											X		Pima Co FCD		ALERT	2159
Pima	Sabino Canyon Dam	32 18 54	110 48 36	2160		X										X	Pima Co FCD	NWS6	ALERT	2160
Pima	Sabino Creek nr Tucson	32 18 24	110 48 06	Unknown		X										X	USGS	USGS	GOES	SABO 16299E4A 09484000
Pima	Sabino Road Bridge	32 15 57	110 50 28	2475											X		Pima Co FCD		ALERT	2123

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Pima	Sabino Road Bridge	32 15 57	110 50 28	2475		X										X	Pima Co FCD	NWS6	ALERT	2120
Pima	Saguaro NM	32 11 00	110 44 00	3100	X	X		X	X	X							NPS	NWS1	NONE	21202
Pima	Salcido Place	32 10 29	110 29 35	4372		X											Pima Co FCD	Pima Co FCD	ALERT	4270
Pima	San Pedro River nr Red	32 22 50	110 26 45	Unknown		X										X	USGS	USGS	GOES	PEDR 16297DB8 09472000
Pima	Santa Cruz River nr Cont	31 52 17	110 58 46	Unknown		X										X	USGS	USGS	GOES	CRZC 16299098 09482000
Pima	Santa Rita Exp Range	31 46 00	110 51 00	4300	X	X											NOAA	NWS4	NONE	7593
Pima	Santa Rosa School	32 21 00	112 04 00	1820		X											COE	COE	METEOR BURST	Unknown
Pima	Sasabe	31 29 00	111 33 00	3590	X	X											NOAA	NWS4	NONE	7619
Pima	Sasabe 6 NNE	31 34 00	111 30 00	3495	X	X										X	NOAA	NWS4	NONE	7625
Pima	Sasabe 7 NW	31 35 00	111 36 00	3825		X											NOAA	NWS4	NONE	7622
Pima	SCR/Canoa	31 44 43	111 02 13	3008											X		Pima Co FCD	Pima Co FCD	ALERT	6063
Pima	SCR/Canoa	31 44 43	111 02 13	3008		X										X	Pima Co FCD	NWS6	ALERT	6060
Pima	SCR/Continental	31 51 11	110 58 35	2856											X		Pima Co FCD	Pima Co FCD	ALERT	6049
Pima	SCR/Continental	32 51 11	110 58 35	2856		X										X	Pima Co FCD	NWS6	ALERT	6050
Pima	SCR/Valencia	32 08 02	110 59 28	2400											X		Pima Co FCD		ALERT	6039
Pima	SCR/Valencia	32 08 02	110 59 28	2400		X											Pima Co FCD		ALERT	6040
Pima	Sierrita Mine	31 53 00	111 07 00	Unknown	X	X		X	X	X							CYPRUS	CYPRUS	NONE	Unknown
Pima	Suguaro	32 20 00	110 40 00	3100	X	X		X	X	X							USFS	BLM	NONE	3233A49C
Pima	Tanque Verde Bridge	32 15 26	110 49 08	2510											X		Pima Co FCD		ALERT	2109
Pima	Tanque Verde Guest Ranch	32 14 47	110 40 46	2720		X										X	Pima Co FCD	NWS6	ALERT	2090
Pima	Tanque Verde Ranch	32 14 47	110 40 46	2720											X		Pima Co FCD		ALERT	2093
Pima	Tanque Verde Road Bridge	32 15 26	110 49 08	2510		X										X	Pima Co FCD	NWS6	ALERT	2110
Pima	Three Points	32 04 33	111 20 16	2551											X		Pima Co FCD		ALERT	6423
Pima	Three Points	32 04 33	111 20 16	2551		X											Pima Co FCD	NWS6	ALERT	6420
Pima	Tinaja Hill	31 48 33	111 05 47	3493		X											Pima Co FCD	Pima Co FCD	ALERT	6340
Pima	Tucson	32 07 00	110 56 00	2584	X	X		X	X	X	X	X				X	NWS4	NWS4	NONE	Unknown
Pima	Tucson	32 16 49	110 56 45	2340	X	X		X	X	X			X	X			AZMET	AZMET	GOES	1
Pima	Tucson 17 NW	32 15 00	111 12 00	2560	X	X										X	NOAA	NWS4	NONE	8795
Pima	Tucson Cmp Ave Exp FM	32 17 00	110 57 00	2329	X	X										X	NOAA	NWS4	NONE	8796
Pima	Tucson Magnetic Obs	32 15 00	110 50 00	2526	X	X										X	NOAA	NWS4	NONE	8800
Pima	Tucson SAWRS	32 08 00	111 10 00	2415	X			X	X		X						NWS3	NWS3	NONE	RYN
Pima	Tucson University of Arizona	32 15 00	110 57 00	2444	X	X										X	NOAA	NWS4	NONE	8815
Pima	Tucson University of Arizona #1	32 16 00	111 00 00	2300	X	X	X										NOAA	NWS4	NONE	8817
Pima	Tucson WSO	32 07 00	110 56 00	2555	X	X		X	X	X	X	X				X	NWS3	NWS3	NONE	72274-TUC
Pima	Tucson WSO Airport	32 08 00	110 56 00	2584	X	X										X	NOAA	NWS4	NONE	8820
Pima	Valhala Park	32 06 16	111 08 04	2585		X											Pima Co FCD	Pima Co FCD	ALERT	6430
Pima	Ventana	32 18 31	110 50 19	2720		X											Pima Co FCD	Pima CO FCD	ALERT	2170

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Pima	White Tail	32 24 44	110 44 04	8400		X											Pima Co FCD		ALERT	2150
Pima	White Tank	32 18 21	110 34 15	4400		X											Pima Co FCD		ALERT	2040
Pinal	Apache FRS	33 26 28	111 33 07	1989												X	MCFCD	NWS6	ALERT	6673
Pinal	Apache FRS	33 26 28	111 33 07	1989		X											MCFCD	NWS6	ALERT	6670
Pinal	Apache Jnctn 5 NE	33 28 00	111 28 00	2070	X	X										X	NOAA	NWS4	NONE	288
Pinal	Apache Junction	33 25 42	111 31 29	1758		X											MCFCD	MCFCD	ALERT	1147
Pinal	Apache Trail	33 25 42	111 31 31	1820		X											MCFCD		ALERT	6675
Pinal	Aravaipa C nr Mamth	32 50 37	110 37 07	Unknown		X										X	USGS	USGS	GOES	AVRM 162AFCA2 09473000
Pinal	Arnett	33 16 00	111 05 00	3500		X											COE	COE	METEOR BURST	Unknown
Pinal	Ashurst Hayden Dam	33 05 00	111 15 00	1638		X											NOAA	NWS4	NONE	498
Pinal	Cadillac Wash	32 40 05	111 03 18	3080											X		Pinal Co	Pinal Co	ALERT	715
Pinal	Casa Grande	32 53 00	111 45 00	1395	X	X										X	NOAA	NWS4	NONE	1306
Pinal	Casa Grande Ruins N M	33 00 00	111 32 00	1420	X	X										X	NOAA	NWS4	NONE	1314
Pinal	Coolidge	32 58 48	111 36 17	1385	X	X		X	X	X			X	X			AZMET	AZMET	GOES	5
Pinal	Durham Wash	32 43 24	111 06 31	2800											X		Pinal Co	Pinal Co	ALERT	710
Pinal	Eloy	32 46 26	111 33 25	1513	X	X		X	X	X			X	X			AZMET	AZMET	GOES	16
Pinal	Eloy 4 NE	32 50 00	111 32 00	1545	X	X										X	NOAA	NWS4	NONE	2807
Pinal	Fig Springs	32 31 44	110 47 37	4815		X											PCFCD	NWS6	ALERT	1060
Pinal	Florence	33 02 00	111 23 00	1505	X	X										X	NOAA	NWS4	NONE	3027
Pinal	Gila River @ Kelvin	33 06 10	110 58 38	Unknown		X										X	USGS	USGS	GOES	GILK 162B0EDC 09474000
Pinal	Golder Ranch	32 32 20	110 45 14	3310		X											Pima Co FCD	NWS6	ALERT	1010
Pinal	Haley Hills	32 56 57	112 10 15	1480	X	X		X	X	X		X					BLM	NWS1	NONE	20904-327D6636
Pinal	Hewitt	33 24 00	111 12 00	3480		X											COE	COE	METEOR BURST	Unknown
Pinal	Horse Camp CN	32 56 15	110 29 46	4080	X	X		X	X	X		X					BLM	NWS1	NONE	20903-327A5198
Pinal	Kearny	33 03 00	110 54 00	1830		X										X	NOAA	NWS4	NONE	4590
Pinal	Kohatk	32 33 00	112 01 00	1680		X											COE	COE	METEOR BURST	Unknown
Pinal	Maricopa 4 N	33 07 00	112 02 00	1160	X	X										X	NOAA	NWS4	NONE	5270 **
Pinal	McClellan Wash	32 10 10	111 21 24												X		Pinal Co	Pinal Co	ALERT	720
Pinal	Olsen Wash	32 46 25	111 09 36	2540											X		Pinal Co	Pinal Co	ALERT	705
Pinal	Oracle 2 SE	32 36 00	110 44 00	4510	X	X											NOAA	NWS4	NONE	6119
Pinal	Oracle Ranger Station	32 35 57	110 47 20	4520		X											Pima Co FCD	NWS6	ALERT	1020
Pinal	Oracle Ridge	32 31 19	110 45 14	6560		X											PCFCD	NWS6	ALERT	1030
Pinal	Picacho 8 SE	32 39 00	111 25 00	1830	X	X										X	NOAA	NOAA	NONE	6513
Pinal	Rancho Solano	32 33 51	110 51 01	3380											X		Pima Co FCD		ALERT	1079
Pinal	Rancho Solano	32 33 51	110 51 01	3380		X										X	PCFCD	NWS6	ALERT	1080
Pinal	Sacaton	33 04 00	111 45 00	1285	X	X										X	NOAA	NWS4	NONE	7370
Pinal	San Manuel	32 37 00	110 39 00	3460		X										X	NOAA	NWS4	NONE	7530

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Pinal	Santa Maria River nr Bagdad	34 18 21	113 20 47	1360	X	X										X	COE	COE	METEOR BURST	CE134148 09424900
Pinal	Superior	33 18 00	111 06 00	2995	X	X										X	NOAA	NWS4	NONE	8348
Pinal	Superior 2 ENE	33 18 00	111 04 00	4155		X											NOAA	NWS4	NONE	8349
Pinal	Tat Momolikot Dam	32 39 03	111 55 40	1558		x										X	COE	COE	METEOR BURST	CE4775A
Santa Cruz	Canelo 1 NW	31 33 00	110 32 00	5010	X	X											NOAA	NWS4	NONE	1231
Santa Cruz	Cherry Springs	32 30 42	110 50 08	4080		X											PCFCD	NWS6	ALERT	1050
Santa Cruz	Elephant Head Butte	31 43 32	110 58 03	3475		X											Pima Co FCD	NWS6	ALERT	6350
Santa Cruz	Elgen	35 15 00	112 37 30	7100	X	X		X	X	X							USFS	BLM	NONE	3260F7AC
Santa Cruz	Nogales 6 N	31 25 00	110 57 00	3560	X	X										X	NOAA	NWS4	NONE	5924
Santa Cruz	Patagonia	31 36 00	110 48 00	4044	X	X		X	X	X							USFS	NWS1	NONE	021301
Santa Cruz	Patagonia 2	31 33 00	110 45 00	4190		X											NOAA	NWS4	NONE	6282
Santa Cruz	Santa Cruz River nr Loc	31 21 19	110 35 20			X										X	USGS	USGS	GOES	09480000
Santa Cruz	Santa Cruz River nr Nogales	31 20 40	110 51 03	Unknown		X										X	USGS	USGS	GOES	09480500
Santa Cruz	SCR/Nogales	31 20 47	110 51 10	3825											X		Pima Co FCD		ALERT	6069
Santa Cruz	SCR/Nogales	31 20 47	110 51 10	3825		X										X	Pima Co FCD	NWS6	ALERT	6070
Santa Cruz	Tumacacori National Monument	31 34 00	111 03 00	3266	X	X										X	NOAA	NWS4	NONE	8865
Yavapai		34 31 07	112 28 11	5857													Yavapai Co	Yavapai Co		Repeater
Yavapai	Agua Fria R nr Mayer	34 18 55	112 03 48	Unknown		X										X	USGS	USGS	GOES	AGUM 162A84E0 095112500
Yavapai	Agua Fria R nr RS	34 04 56	112 10 02	Unknown		X										X	USGS	USGS	GOES	AGUR 162A9796 09512800
Yavapai	Ash Fork 2	35 13 00	112 29 00	5130		X										X	NOAA	NWS4	NONE	487
Yavapai	Bagdad	34 35 00	113 10 00	3710	X	X											NOAA	NWS4	NONE	586
Yavapai	Bagdad	34 35 54	113 12 10	Unknown		X											USGS	USGS	GOES	343554113121000
Yavapai	Bagdad	34 55 35	113 12 21	4160	X	X											COE	COE	METEOR BURST	CE474EE2
Yavapai	Bannon Creek	34 30 54	112 27 52	5622											X		YCFCD	Yavapai	ALERT	318
Yavapai	Bannon Creek	34 30 54	112 27 52	5622		X											YCFCD	Yavapai	ALERT	315
Yavapai	Beaver Creek	34 42 00	111 48 00	3820	X	X		X	X	X							USFS	NWS1	NONE	020505-32338270
Yavapai	Beaver Creek RS	34 40 00	111 43 00	3820	X	X											NOAA	NWS4	NONE	670
Yavapai	Camp Verde	34 33 00	111 51 00	3170	X	X		X	X	X							USFS	NWS1	NONE	020503
Yavapai	Campwood	34 48 16	112 52 39	5670	X	X											COE	COE	METEOR BURST	CE22800C CE22800C
Yavapai	Campwood	34 48 16	112 52 39	Unknown		X											USGS	USGS	GOES	344816112523900
Yavapai	Castle Hot Springs	33 59 00	112 22 00	1990	X	X											NOAA	NWS4	NONE	1353
Yavapai	Childs	34 20 59	111 41 55	Unknown		X											USGS	USGS	GOES	342059111415500
Yavapai	Childs	34 21 00	111 42 00	2650	X	X										X	NOAA	NWS4	NONE	1614
Yavapai	Chino	34 48 00	112 24 00	4673	X	x		X	X	X							USFS	NWS1	NONE	20504
Yavapai	Chino Valley	34 45 00	112 27 00	4748	X	X										X	NOAA	NWS4	NONE	1654
Yavapai	Copper Basin	34 29 00	112 33 00	5280	X	X		X	X	X							USFS	BLM	NONE	324006C6
Yavapai	Copper Basin Divide	34 30 00	112 33 00	6720		X										X	SCS	SCS	METEOR BURST	12R06

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Yavapai	Cordes	34 18 00	112 10 00	3771	X	X										X	NOAA	NWS4	NONE	2109
Yavapai	Cottonwood Crk Wad	33 53 55	112 18 39	Unknown		X										X	USGS	USGS	GOES	COTW 162AACDE 09512970
Yavapai	Crook Trail nr Pine	34 29 46	111 34 26	Unknown		X											USGS	USGS	GOES	342946111342601
Yavapai	Crown King	34 12 00	112 20 00	5920	X	X											NOAA	NWS4	NONE	2329
Yavapai	Crown King	34 12 00	112 21 00	6000	X	X		X	X	X							USFS	NWS1	NONE	20502
Yavapai	Crown King	34 12 50	112 21 14	6783		X											MCFCD	NWS6	ALERT	5715
Yavapai	Crown King	34 12 50	112 21 14	6783	X												MCFCD	NWS6	ALERT	5718
Yavapai	Dewey	34 30 21	112 08 32	4775		X											MCFCD	NWS6	ALERT	5805
~~Yavapai~~	~~Dry Beaver Cr nr Rim~~	~~34 43 43~~	~~111 46 30~~	~~Unknown~~		~~X~~										~~X~~	~~USGS~~	~~USGS~~	~~GOES~~	~~DBEV 162A41FE 09505350~~
Yavapai	Francis Mountain	34 29 00	112 36 00	7110	X	X		X	X	X							USFS	BLM	NONE	32400814
Yavapai	Garfias Mtn.	33 57 55	112 25 43	2645		X											MCFCD	NWS6	ALERT	5670
Yavapai	Goodwin Mesa	34 45 00	113 18 00	4200	X	X		X	x	x		X					BLM	NWS1	NONE	20507-324C62BC
Yavapai	Hassayampa Bridge	34 18 38	112 34 05	3744												X	MCFCD	NWS6	ALERT	51
Yavapai	Hassayampa Bridge	34 18 38	112 34 05	3785		X											MCFCD	NWS6	ALERT	5350
Yavapai	Hassayampa Bridge	34 18 38	112 34 05	3785		X											MCFCD	NWS6	ALERT	5353
Yavapai	Hillside 4 NNE	34 29 00	112 53 00	3320	X	X										X	NOAA	NWS4	NONE	4053
Yavapai	Horner Mtn. Ranch	34 31 53	111 56 44	4407		X											MCFCD	NWS6	ALERT	5760
Yavapai	Horseshoe Ranch	34 13 50	112 00 00	3805		X											MCFCD	NWS6	ALERT	5745
Yavapai	Humbug Creek	34 05 00	112 18 00	5250	X	X		X	X	X		X					BLM	NWS1	NONE	20508-327CF1AE
Yavapai	I-17 @ 169	34 31 10	112 00 02	4750		X											MCFCD	NWS6	ALERT	5790
Yavapai	Iron Springs	34 30 00	112 30 00	5920	X	X		X	X	X							USFS	NWS1	NONE	20501-323387EA
Yavapai	Jerome	34 45 00	112 06 00	4950	X	X											NOAA	NWS4	NONE	4453
Yavapai	Lower Goldwater	34 29 56	112 27 24	5933											X		YCFCD	NWS6	ALERT	313
Yavapai	Lower Goldwater	34 29 56	112 27 24	5933		X											YCFCD	NWS6	ALERT	310
Yavapai	Mingus Mountain	34 42 00	112 08 00	7100												X	SCS	SCS	METEOR BURST	12R03
Yavapai	Montezuma Castle	34 36 36	111 50 14			X											USGS	USGS	GOES	343636111501400
Yavapai	Montezuma Castle NM	34 37 00	111 50 00	3179	X	X										X	NOAA	NWS4	NONE	5635 **
Yavapai	Mountain Springs	34 06 00	111 36 00	5000	X	X		X	X	X							USFS	NWS1	NONE	020506
Yavapai	Mt. Union	34 24 47	112 24 54	7495		X											MCFCD	NWS6	ALERT	5380
Yavapai	Mt. Union	34 24 47	112 24 54	7495	X												MCFCD	NWS6	ALERT	5383
Yavapai	Mt. Union	34 24 54	112 24 17	7495												X	MCFCD	NWS6	ALERT	5385
Yavapai	Prescott	34 34 00	112 26 00	5205	X	X										X	NOAA	NWS4	NONE	6796
Yavapai	Prescott FSS	34 39 00	112 26 00	5052	X	X		X	X	X	X	X		X		X	NWS3	NWS3	NONE	PRC
Yavapai	Prescott Valley	34 40 43	112 15 16	5228		X											MCFCD	NWS6	ALERT	5820
Yavapai	Saw Mountain	34 29 12	112 29 05	6016		X											Yavapai Co	NWS6	ALERT	320
Yavapai	Seligman	35 19 00	112 53 00	5250	X	X											NOAA	NWS4	NONE	7716
Yavapai	Sierra Prieta	34 30 18	112 33 12	6917		X											YCFCD	Yavapai	ALERT	345

COUNTY	STATION NAME	LATITUDE	LONGITUDE	ELEVATION	TE	PR	EV	WS	WD	RH	DP	BP	ST	SR	PT	OT	OWNER	OPERATOR	TRANSMISSION MODE	ID NUMBER
Yavapai	Skull Valley	34 35 50	112 38 10	5190	X	X											COE	COE	METEOR BURST	CE473872
Yavapai	Skull Valley	34 35 50	112 38 10	Unknown		X											USGS	USGS	GOES	343550112381000
Yavapai	Stanton (RAWS)	34 10 00	112 44 00	3600	X	X		X	X	X		X					BLM	NWS1	NONE	20509-324C5726
Yavapai	Turkey Creek nr Cle	34 16 56	112 12 25	Unknown		X										X	USGS	USGS	GOES	TURK 162A8A32 09512600
Yavapai	Turtle People	34 29 00	112 24 52	6857		X											YCFCD	NWS6	ALERT	305
Yavapai	Tuzigoot National Monument	34 46 00	112 02 00	3470	X	X											NOAA	NWS4	NONE	8904
Yavapai	West Circle Creek nr Cmp	34 32 19	111 41 36	Unknown		X										X	USGS	USGS	GOES	09505800
Yavapai	White Spar Camp	34 30 22	112 28 39	5608											X		Yavapai Co	Yavapai Co	ALERT	328
Yavapai	Wilhoit	34 26 36	112 36 47	5043		X													ALERT	5365
Yavapai	Williams Peak	34 31 59	112 32 53	6340		X											YCFCD	Yavapai	ALERT	350
Yavapai	Wolverton Mountain	34 30 13	112 30 34	6661		X											YCFCD	NWS6	ALERT	330
Yavapai	Y.C.F.C.D. Yard	34 32 00	112 27 58	5473		X											YCFCD	Yavapai	ALERT	335
Yavapai	Yarnell Hill	34 13 21	112 44 53	5128		X											MCFCD	NWS6	ALERT	5290
Yuma	Baragan Wash	32 58 03	113 26 58	485	X	X		X	X	X		X					BLM	NWS1	NONE	020702-327D53AC
Yuma	Dateland	32 59 09	113 29 48	163	X	X		X	X	X			X	X			AZMET	AZMET	GOES	17
Yuma	Dateland Whitewing R	32 59 00	113 30 00	545	X	X										X	NOAA	NWS4	NONE	2434
Yuma	Gila River nr Mohawk	32 47 18	113 45 48	Unknown		X										X	USGS	USGS	GOES	09520360
Yuma	Gila Rvr nr Mohawk	32 47 18	113 45 48	295		X										X	COE	COE	METEOR BURST	CE43523E 09520330
Yuma	Kofa Mine	33 16 00	113 52 00	1775	X	X										X	NOAA	NWS4	NONE	4702
Yuma	Kofa Mountains	33 16 00	113 52 00	1780	X	X											NOAA	NWS4	NONE	4702
Yuma	Tacna	32 43 00	113 55 00	324	X	X										X	NOAA	NWS4	NONE	8396
Yuma	Yuma	32 40 00	114 36 00	196	X	X		X	X	X	X	X	X			X	NWS4	NWS4	NONE	Unknown
Yuma	Yuma	32 40 00	114 36 00	206	X	X		X	X		X	X	X			X	NWS3	NWS3	NONE	72280-YUM
Yuma	Yuma	32 40 12	114 37 48	206	X	X		X	X	X		X					BLM	NWS1	NONE	20701
Yuma	Yuma Citrus Station	32 37 00	114 39 00	191	X	X	X									X	NOAA	NWS4	NONE	9652
Yuma	Yuma Mesa	32 36 43	114 38 02	191	X	X		X	X	X			X	X			AZMET	AZMET	GOES	3
Yuma	Yuma North Gila	32 44 07	114 31 46	145	X	X		X	X	X			X	X			AZMET	AZMET	GOES	14
Yuma	Yuma Proving Ground	32 50 00	114 24 00	324	X	X										X	NOAA	NWS4	NONE	9654
Yuma	Yuma Valley	32 42 45	114 42 18	114	X	X		X	X	X			X	X			AZMET	AZMET	GOES	2
Yuma	Yuma Valley	32 43 00	114 43 00	120	X	X										X	NOAA	NWS4	NONE	9657
Yuma	Yuma WSO Airport	32 40 00	114 36 00	206	X	X										X	NOAA	NWS4	NONE	9660

APPENDIX B

ENABLING LEGISLATION ARS 45:1501-1506

Conference Engrossed

FILED
ARIZONA
SECRETARY OF STATE

State of Arizona
House of Representatives
Forty-first Legislature
Second Regular Session
1994

CHAPTER 224

HOUSE BILL 2192

AN ACT

AMENDING TITLE 45, CHAPTER 8, ARIZONA REVISED STATUTES, BY ADDING ARTICLE 6; MAKING APPROPRIATIONS FOR FLOOD CONTROL AND RELIEF; RELATING TO FLOOD CONTROL.

Be it enacted by the Legislature of the State of Arizona:

Section 1. Title 45, chapter 8, Arizona Revised Statutes, is amended by adding article 6, to read:

ARTICLE 6. FLOOD WARNING SYSTEMS

45-1501. Definitions

IN THIS ARTICLE, UNLESS THE CONTEXT OTHERWISE REQUIRES:

1. "FLOOD WARNING SYSTEM" MEANS A PROJECT OR SERIES OF PROJECTS TO DETECT FLOODS AND DEVELOP FLOOD PREPAREDNESS PLANS AND MAY INCLUDE THE SYSTEM KNOWN AS THE AUTOMATIC LOCAL EVALUATION IN REAL TIME SYSTEM.

2. "LOCAL ENTITY" MEANS A CITY, TOWN, COUNTY, POLITICAL SUBDIVISION OR DRAINAGE AND FLOOD CONTROL DISTRICT ORGANIZED UNDER TITLE 48, CHAPTER 18 OR 21 OR ANY OTHER SPECIAL TAXING DISTRICT ORGANIZED UNDER TITLE 48.

45-1502. Powers and duties

A. THE DIRECTOR MAY:

1. COOPERATE AND COORDINATE WITH THE FEDERAL GOVERNMENT OR ANY OF ITS DEPARTMENTS OR AGENCIES AND LOCAL ENTITIES TO ESTABLISH A FLOOD WARNING SYSTEM FOR THIS STATE.

2. DISBURSE MONIES FROM THE FLOOD WARNING SYSTEM FUND PURSUANT TO SECTION 45-1504.

3. PROVIDE TECHNICAL ASSISTANCE TO LOCAL ENTITIES TO DEVELOP AND MAINTAIN A FLOOD WARNING SYSTEM FOR THIS STATE.

4. EMPLOY STAFF TO PROVIDE TECHNICAL ASSISTANCE.

5. ENTER INTO INTERGOVERNMENTAL AGREEMENTS FOR THE PURPOSES STATED IN THIS ARTICLE.

45-1503. Flood warning system fund

A. A FLOOD WARNING SYSTEM FUND IS ESTABLISHED IN THE STATE TREASURY FOR DEVELOPING A FLOOD WARNING SYSTEM, PURCHASING FLOOD WARNING SYSTEM EQUIPMENT AND PROVIDING ASSISTANCE TO LOCAL ENTITIES ON A COST SHARING BASIS FOR THE PLANNING, DESIGN, INSTALLATION, OPERATION AND MAINTENANCE OF FLOOD WARNING SYSTEMS. THE DIRECTOR SHALL ADMINISTER THE FUND.

B. THE FLOOD WARNING SYSTEM FUND SHALL CONSIST OF MONIES FROM LEGISLATIVE APPROPRIATIONS, GRANTS AND CONTRIBUTIONS FROM OTHER PUBLIC AGENCIES.

C. ON NOTICE FROM THE DIRECTOR, THE STATE TREASURER SHALL INVEST AND DIVEST MONIES IN THE FUND AS PROVIDED BY SECTION 35-313 AND MONIES EARNED FROM INVESTMENT SHALL BE CREDITED TO THE FUND.

D. MONIES IN THE FUND ARE EXEMPT FROM LAPSING UNDER SECTION 35-190.

45-1504. Flood warning system grants

A. THE DIRECTOR MAY MAKE GRANTS FROM THE FLOOD WARNING SYSTEM FUND ESTABLISHED BY SECTION 45-1503 TO LOCAL ENTITIES ELIGIBLE FOR FLOOD WARNING SYSTEM ASSISTANCE UNDER THIS ARTICLE TO DEFRAY THE COST TO THE LOCAL ENTITY OF THE FOLLOWING:

1. PLAN AND DESIGN OF A FLOOD WARNING SYSTEM.

2. PURCHASE OF EQUIPMENT NECESSARY TO INSTALL A FLOOD WARNING SYSTEM.

3. INSTALLATION OF FLOOD WARNING SYSTEM EQUIPMENT.

4. INITIAL OPERATION OF THE SYSTEM INCLUDING HYDROLOGIC AND HYDRAULIC MODELING AND SYSTEM CALIBRATION.

B. ON APPLICATION, THE DIRECTOR SHALL MAKE A FULL AND CAREFUL INVESTIGATION OF THE QUALIFICATIONS OF THE APPLICANT AND THE PROPOSED PROJECT. THE DIRECTOR SHALL DETERMINE WHETHER THE PROPOSED FLOOD WARNING SYSTEM WOULD PROVIDE MEANINGFUL FLOOD WARNING AND IS IN THE BEST INTEREST OF THIS STATE.

C. NO GRANT MAY BE FOR MORE THAN SEVENTY-FIVE PER CENT OF THE COST OF EQUIPMENT NECESSARY TO INSTALL THE FLOOD WARNING SYSTEM.

D. EACH GRANT SHALL BE EVIDENCED BY AN INTERGOVERNMENTAL AGREEMENT BETWEEN THE LOCAL ENTITY AND THE DIRECTOR, ACTING ON BEHALF OF THIS STATE.

E. GRANTS MAY BE AWARDED SUBJECT TO THIS ARTICLE IN THE MANNER AND ON THE TERMS AND CONDITIONS AS MAY BE PRESCRIBED BY THE DIRECTOR.

F. THE DIRECTOR SHALL NOT GRANT ANY MONIES FROM THE FLOOD WARNING SYSTEM FUND TO A LOCAL ENTITY IN AN AREA FOR WHICH THE APPROPRIATE PUBLIC AGENCY HAS FAILED TO ADOPT AND ENFORCE FOR ITS AREA OF JURISDICTION FLOODPLAIN REGULATIONS REQUIRED BY TITLE 48, CHAPTER 21.

G. GRANTS MAY BE MADE DIRECTLY TO THE DIRECTOR PURSUANT TO THIS SECTION FOR THE PURPOSE OF PLANNING, DESIGNING, INSTALLING, OPERATING AND MAINTAINING A FLOOD WARNING SYSTEM. GRANTS MADE DIRECTLY TO THE DIRECTOR SHALL BE EVIDENCED BY A WRITTEN SCOPE OF WORK.

45-1505. Operation and maintenance of flood warning system

A. THE LOCAL ENTITY WITH AN INTERGOVERNMENTAL AGREEMENT WITH THE DIRECTOR REGARDING A COMPONENT OF A FLOOD WARNING SYSTEM IS RESPONSIBLE FOR THE OPERATION AND MAINTENANCE OF THAT COMPONENT.

B. THE DIRECTOR MAY PROVIDE TRAINING, TECHNICAL ASSISTANCE AND ONGOING OVERSIGHT TO THE LOCAL ENTITY RESPONSIBLE FOR A COMPONENT OF THE FLOOD WARNING SYSTEM.

C. IF MAINTENANCE OF A COMPONENT OF THE FLOOD WARNING SYSTEM IS REQUIRED AND THE LOCAL ENTITY WITH AN INTERGOVERNMENTAL AGREEMENT WITH THE DIRECTOR FOR THAT COMPONENT DOES NOT COMPLETE THE REQUIRED MAINTENANCE

1 WITHIN FIFTEEN DAYS OF WRITTEN NOTICE OF THE REQUIRED MAINTENANCE FROM THE
2 DIRECTOR, THE DIRECTOR MAY COMPLETE THE REQUIRED MAINTENANCE.
3 D. IN THE DIRECTOR'S SOLE DISCRETION, THE DIRECTOR MAY CHARGE A
4 LOCAL ENTITY FOR THE COSTS ACTUALLY INCURRED IN COMPLETING REQUIRED
5 MAINTENANCE OR PROVIDING ONGOING OVERSIGHT OF THE OPERATION AND
6 MAINTENANCE OF A COMPONENT OF THE FLOOD WARNING SYSTEM. ON BEHALF OF THE
7 DEPARTMENT, THE ATTORNEY GENERAL MAY COMMENCE WHATEVER ACTIONS ARE
8 NECESSARY TO COLLECT PAYMENT OF CHARGES IMPOSED PURSUANT TO THIS
9 SUBSECTION.
10 45-1506. Immunity of state from liability for losses
11 THIS STATE, ITS DEPARTMENTS, AGENCIES, OFFICIALS, EMPLOYEES AND
12 AGENTS AND ANY LOCAL ENTITIES AS DEFINED IN SECTION 45-1501 ARE IMMUNE
13 FROM LIABILITY FOR LOSSES ARISING FROM DAMAGE, THEFT, CHANGE OF LOCATION
14 OR THE PARTIAL OR TOTAL FAILURE OF ANY PLAN, DESIGN, INSTALLATION,
15 OPERATION OR MAINTENANCE OF A FLOOD WARNING SYSTEM.
16 Sec. 2. Appropriations; purpose
17 A. The sum of $150,000 is appropriated from the state general fund
18 to the flood warning system fund established by section 45-1503, Arizona
19 Revised Statutes, as added by this act, in fiscal year 1994-1995 for the
20 establishment and support of the flood warning system prescribed by this
21 act.
22 B. The sum of $150,000 is transferred from the flood control loan
23 fund established by section 45-1492, Arizona Revised Statutes, to the
24 flood warning system fund established by section 45-1503, Arizona Revised
25 Statutes, as added by this act, in fiscal year 1994-1995 for the
26 establishment and support of the flood warning system prescribed by this
27 act. Notwithstanding the provisions of section 45-1492, Arizona Revised
28 Statutes, the transfer of monies pursuant to this section is not a loan
29 and repayment to the flood control loan fund is not required.
30 Sec. 3. Appropriations; purposes; exemption
31 The sum of $5,050,000 is appropriated from the state general fund to
32 the division of emergency management of the department of emergency and
33 military affairs in the following amounts for the purposes specified:
34 1. The sum of $5,000,000 for fiscal year 1994-1995 to provide the
35 required fifteen per cent matching monies for flood relief public
36 assistance in Apache, Cochise, Coconino, Gila, Graham, Greenlee, Maricopa,
37 Navajo, Pima, Pinal, Santa Cruz, Yavapai and Yuma counties. The
38 appropriation shall be used to implement elements of the federal and state
39 agreement signed on January 26, 1993 pursuant to the disaster relief and
40 emergency assistance act, P.L. 93-288, as amended, declaring thirteen
41 Arizona counties eligible for federal disaster assistance.
42 2. The sum of $50,000 for fiscal year 1994-1995 for the
43 establishment of a full-time state hazard mitigation officer.
44 Sec. 4. Legislative intent
45 The legislature intends to appropriate monies pursuant to section 3
46 of this act to fund the political subdivision's portion of the match
47 requirement for reconstruction and repair projects as a result of flooding
48 pursuant to the disaster relief and emergency assistance act, P.L. 93-288,

as amended, for the fiscal year in which the costs are incurred after completion and audit of the projects.

Sec. 5. Appropriation; purpose; match

The sum of $500,000 is appropriated in fiscal year 1994-1995 from the state general fund to the department of transportation for distribution to Pima county flood control district to provide flood control works protecting the town of Marana on the Santa Cruz river in the vicinity of the Avra Valley road bridge. The appropriation is contingent on an equal match from the Pima county flood control district.

Sec. 6. Appropriation; purpose; contingency

The sum of $1,250,000 is appropriated in fiscal year 1994-1995 from the state general fund to the department of transportation for distribution to Pima county to replace the Avra Valley road bridge across the Santa Cruz river. The appropriation is contingent on an equal match from Pima county.

Sec. 7. Reversion; appropriations

Notwithstanding any other provision of law, on the effective date of this act, the following sums from the designated appropriations revert to the state general fund:

1. The $500,000 appropriated by Laws 1984, chapter 174, section 4, subsection D to the department of transportation for the purpose of replacing the Avra Valley road bridge across the Santa Cruz river and to increase the capacity to withstand a one hundred year flood.

2. The $1,398,708.16 remaining of the $1,478,000 appropriated by Laws 1985, chapter 332, section 3, paragraph 2, subdivision (a), item (i) to the department of transportation to be disbursed to the Pima county flood control district to replace a destroyed bridge across the Santa Cruz river in a low flood hazard area at either Sunset road or Orange Grove road.

Sec. 8. Lapsing

A. The appropriation made by paragraph 1 of section 3 of this act is exempt from the provisions of section 35-190, Arizona Revised Statutes, relating to lapsing of appropriations.

B. The appropriations made by sections 5 and 6 of this act shall not lapse until the purposes for which the appropriations are made are accomplished, except that any monies remaining unexpended or unencumbered on July 1, 1997 revert to the state general fund.

Sec. 9. Emergency

This act is an emergency measure that is necessary to preserve the public peace, health or safety and is operative immediately as provided by law.

APPROVED BY THE GOVERNOR APRIL 21, 1994

FILED IN THE OFFICE OF THE SECRETARY OF STATE APRIL 25, 1994

APPENDIX C

OUT-OF-STATE INTERVIEW REPORTS

Out-Of-State Interview Reports

Oklahoma Climatological Survey Mesonet
Pennsylvania Emergency Management Agency
Urban Drainage and Flood Control District of Denver, Colorado
Harris County Flood Control District, Texas
City of Austin, Texas Flood Early Warning System
City of Tulsa, Oklahoma Flood Warning System
City of Dallas, Texas River Levee Operations
Pikes Peak Flash Flood Warning System
Colorado Springs, Colorado

Federal Agencies
National Severe Storms Laboratory - Norman, Oklahoma
NWS Techniques Development Laboratory - Camp Springs, Maryland
River Forecast Centers
Western Region Headquarters

ASSESSMENT OF OUT-OF-STATE FLOOD WARNING SYSTEM

Name Flood Warning System: Oklahoma Climatological Survey Mesonet
Location of FWS: University of Oklahoma, 100E. Boyd, Suite 1210, Norman, Oklahoma, (405) 325-2541
Key Contacts: Dr. Ken Crawford and David Shellberg (Deceased 11/94)

1. **What is the physical configuration of the system?** Statewide environmental monitoring network used by National Weather Service for verification of NEXRAD radar precipitation products and to communicate flash flood watches and warning.

2. **What is the basic design of the system?** 111 environmental monitoring sites uniformly distributed across the state in each of 77 counties. Average station spacing is 19 miles. Use Oklahoma Law Enforcement Telecommunications Network (OLETS), to transfer environmental mesonet data to redundant CPU's located in Norman (OCS) and Oklahoma State University Stillwater .See

3. **What is the motivation and source of the system?** The motivation for the systems comes from the frequent occurrence of severe weather in Oklahoma and the need for surface weather data on meso scale to assist in its prediction. The source of the system came from a cooperative agreement between the two state universities.

4. **What was the installation procedure?** The system was design and installed internally by the cooperative university staffs though OCS staff installed most of the sites. Indicated it was much (10X) to install system than outside.

5. **What types of data are used as input to the system?**

   Weather:

   Environmental sites:Temperature (1.5m,10m), dew point, wind direction/speed (2m, 10m), solar, pyranometer, leaf wetness, soil temperature, and evaporation.

   NOAA Weather Wire: NWS Oklahoma public products and climatological data

   Precipitation: Rainfall every 0.01"

   Hydrological: Soil moisture content

   Communications: Radio link to OLETS then landline to CPU's

6. **Decision-making - do you issue internal warnings?:** No internal warnings used or generated only National Weather Service Severe Weather/ flash flood watches and warnings as released to NOAA Weather Wire. NWS uses the Mesonet to assist in

issuing severe weather and flash flood watches/warnings and verify WSR-88D doppler radar precipitation products.

7. **What types of users do you support?** The Mesonet provides two services: Service to local/state/federal governments, public/private schools and for-profit businesses; and support to public relations through interactive kiosks located at the State Capital and on the University of Oklahoma and Oklahoma State University Campuses.

8. **What types of products does the system prepare routinely?** Most of the products the system produces are products prepared off the raw observations gathered from the environmental sites. Most users have an interactive session through modem hook-up and can "design" product displays to meet their needs.

9. **Do you have a budget cost analysis for the FWS?**

   Development: $2.2 million to design and develop over 2 years
   Installation: $1.1 million
   Operation: $800,000 per year
   Maintenance: $350,000
   Training: 0
   FTE's: 5 to 8 full-time equivalents at OCS and at OSU.

10. **What is the basic funding source for the FWS?** The project was initially funded through the application for energy conservation proposals funded through oil industry over-charge funds ($2.2M) from the Dept. of Energy by the two Oklahoma universities who each contributed $700,000 to the start-up fund. Since this project started the data base it generates has been used to obtain about $4 million dollars of research funding per year and generate about $5-7 million of saving in the state agriculture and energy industries.

11. **How often is the FWS used to support flooding support decision-making?** The National Weather Service uses observations from the Mesonet daily to assist in the preparation of public forecasts and is used as primary source of information in concert with NWS WSR-88D radars to issue and verify flash flooding and flooding.

12. **What is the user satisfaction level?** Very, very very high!!!!!!!

13. **What is your systems operations satisfaction level?** The users and operators are both very satisfied....the Mesonet recently had a 99.95% observation rate...though the system is constantly being improved to make it user-friendly.

14. **If you were starting over what would you do differently?**
Nothing!!

15. **Do you prepare or do you have flood warning responsibilities?**
None directly but serve to re-disseminate NWS flood/flash flood watches and warnings as they appear on NOAA Weather Wire. :Local WFO indicates that the Mesonet has significantly assisted in improving both forecast and observation products in the state.

16. **What are the legal implications of the services provided?**
NONE!!!!! A disclaimer is attached to each application to the Mesonet...see attached application form for the wording.

17. **Has the systems been tested by a recent flooding situation?**
Numerous severe weather and heavy rainfall events have "tested" the system but since it is not design solely as a flash flood or flood detection of warning system this question does not exactly apply.

18. **How has it performed?** The system has been functional since March 1994 and has been "on-air" 99.95% of the time with both observations and product dissemination.

19. **Are there alternative uses of your system which help justify its existence and funding?** Many alternative uses with direct application to Arizona are being used daily in this system. The generation of about $10 million dollars annually in combined research grant funding and agricultural/energy savings. **See copy of attach brochure on the Mesonet!**

The Oklahoma Mesonet is a very important model consideration for the design of the Arzona Statewide Network. It is a cash-generator rather than a cash sink! A copy of the very well-written brochure which describes most of the facets of the Mesonet is attached in this appendix. It will answer most of your questions.

ASSESSMENT OF OUT-OF-STATE FLOOD WARNING SYSTEM

Name of Flood warning System: Pennsylvania Emergency Management Agency (PEMA) State Flood Warning System

Location of FWS: Transportation and Safety Building, P.O. Box 3321, Harrisburg, Pennsylvania 17105-3321 (717) - 783-8150

Key Contacts: John Bahnweg, Emergency Operations Center Coordinator Richard Kenyon, IFLOWS Officer, Brian Greenway, Warning/ Communications Officer, Bureau of Operations

1. **What is the physical configuration of the system?** Statewide flood/severe weather/winter storm warning dissemination and detection network. The systems is based on the NWS IFLOWS system which is basically an ALERT type rain gauge system. The IFLOWS units are installed in 30 of the state's 67 counties. All counties are served by unique two-way interactive satellite dissemination system. The system contains 230 raingauges and 6 stream gauges. The **systems does not have a redundant central procession unit which has led to occasional problems** during severe weather situations.

2. **What is the basic design of the system?** The IFLOWS rain/stream gauge unit reports into the county base station by radio, the county base station prepares the report for dissemination to the central processing unit (CPU) at PEMA in Harrisburg via satellite. The data is processed and quality controlled at the CPU. The CPU also receives NWS weather observations, forecasts and severe weather products from the NWS NOAA Weather Wire. The CPU selects products off a county prepared menu as they are received from the NWS NOAA Weather Wire feed and relays them back to the county base station. **PEMA receives satellite and radar information from Weather Service International (WSI)** , a private weather data broker, and quantitative precipitation forecasts for basin-specific locations from Air Science Consultants to supplement NWS forecasts and products and aid in decision-making.

3. **What is the motivation and source of the system?** The flooding associated with Hurricane Agonies and the Devastating Johnstown Flash Flood of 1977 were instrumental in the establishment of the five state IFLOWS network by the NWS in 1978 and 1979. Pennsylvania was the first applicant to be accepted into the IFLOWS and it continues to receive an unusually strong degree of support, both fiscally and operationally, from the NWS. The IFLOWS system, comprised of 230 rain gauges was installed by the NWS. In 1989 the State of Pennsylvania passed a legislated mandate to disseminate severe weather forecasts and warnings to its citizens. It also legislated a hazardous materials highway use tax to pay for the system. The 60 county satellite dissemination system was jointly funded by NWS and PEMA. Both the IFLOWS and the satellite dissemination system are maintained by PEMA.

4. **What was the installation procedure?** The NWS installed the entire IFLOWS system at a cost of between $1.0 - $1.5 million dollars. PEMA assisted in the site selection for the IFLOWS rain gages. PEMA installed the entire satellite information dissemination/reception system with state HAZMET funds.

5. **What types of data are used as input to the system?**

   Weather: NWS NOAA Weather Wire is the primary source of weather data. It carries a combination of forecasts, observations and severe weather watches/warnings for the entire and surrounding states. For each county a menu is prepared for those products deemed most important to that county. The county has the choice of receiving only those selected products or the entire NOAA Weather Wire suite. **Additionally value-added quantitative precipitation forecasts are prepared for each state basin by Air Science Consultants and issued daily to supplement NWS products.**

   Additionally they receive both satellite and radar data feeds from WSI which are used to keep track a hazardous weather systems and thunderstorm systems as they cross the state. The radar and satellite data are used to alert counties in watch areas of impending severe weather or flooding problems.

   Precipitation: All precipitation data from the NWS IFLOWS sites is received.

   Hydrological: PEMA added 6 stream gauges statewide to the network - its first - during 1994 and the need for more is a severe detriment to monitoring stream and river flows.

   Communications: The PEMA communications network consists of a CPU located at the PEMA headquarters in Harrisburg. A unique satellite communications systems has been established. It features a primary PEMA transmission hub which is linked to a Hughes KU band satellite dish and base station in each county. The system is interactive with the county base station receiving IFLOWS data via radio or landline. This data is in turn transmitted immediately to the CPU. IN turn as NOAA Weather Wire products arrive at the Harrisburg CPU selected on the county menu they are transmitted to the county base station.

6. **Decision-making - do you issue internal warnings?: Yes and no.** The PEMA central operations center relies heavily on the NWS watch and warning system for alerting counties to the flash flow risk. All watches and warning are relayed via satellite and verified by telephone of receipt....ditto warnings. The PEMA uses **radar** to monitor severe thunderstorm systems with flash flooding threat and will place pro-active phone calls to county EOC's to alert them to the storm's approach.

The Value added QPF's are also used to issue internal warnings when the situation requires, i.e., NWS has not issued a timely warning and flash flood guidance values are either about to be or have been exceeded. This pro-active internal warning state is unique among statewide FWS.

7. **What types of users do you support?** Primary support is given to the 67 state EOC's but support is also given to the State Highways and Public Works departments in the form of weather forecasts to assist in highway safety and road maintenance programs. The satellite system is used to relay information on HAZMET problems and by the State Police and Local Law Enforcement communities to transfer operations information.

8. **What types of products does the system prepare routinely? No internal products are prepared.**

9. **Do you have a budget cost analysis for the FWS?**

   Development: NWS installed IFLOWS at a cost of an estimated $1.5 million while the satellite systems cost about $10,500 per site or about $750,000.
   Installation: see above.
   Operation: $1.5million per year. Each EOC hub costs $115/month for maintenance and $200/month for satellite transmission costs. 17 LATA (Joint EOC/State Police/ State Highway) hubs cost $830/month. Total transmission cost runs $0.5million while it was estimated a parallel landline system would run $11.1 million/year.
   Maintenance: $115/EOC hub. NWS picks up the IFLOWS maintenance costs.
   Training: None
   FTE's: 14 full time personnel. 2/shift at ops center, at times 4, 3 EIS maintenance/communications, 4 administrative.

10. **What is the basic funding source for the FWS ?** NWS provides an estimated 0.25 million annually to support the IFLOWS. The rest of the cost is covered by a state highway hazardous materials transportation tax paid for truckers and railroad businesses.

11. **How often is the FWS used to support flooding support decision-making?** Almost monthly with the heaviest usage during the April to October period. Since both stream flash flooding and river flooding problems exist the monitoring program is a daily intensive activity. The NWS uses the IFLOWS to issue in concert with WSR-88D radar products all watches and warnings.

12. **What is the user satisfaction level?** Fairly high but the PEMA can only maintain the existing IFLOWS network not expand it. This problem has lead to less than adequate coverage of the state's rivers streamflow and barely adequate rain gauge coverage.

Note: Maricopa County's ALERT network maintains more sensors than the entire PEMA IFLOWS.

13. **What is your systems operations satisfaction level?** The satellite system has a 99.6% on-line status record which is a source of delight. As earlier indicated the poor IFLOWS coverage is a problem during flash flood season. Availability of radar at the EOC level is about to become an issue as EOC's want doppler pictures during severe weather situations near large metro areas. Other County EOC's consider the problem and severe weather warning "a pain" and are dis-interested.

14. **If you were starting over what would you do differently?** Two primary considerations were identified. First, the PEMA would specify a redundant CPU set-up. The current single CPU occasionally fails during severe weather or power failures despite back-up power. Second, while the IFLOWS funding contribution is nice the state does not own or control the sensors and cannot add sensors to the system. It is caught in a nightmare catch-22 because the existing sensor network is not adequate for needs yet they cannot expand the number of sensors because of NWS control and NWS budget restrictions.

15. **Do you prepare or do you have flood warning responsibilities?** NWS watches and warnings are heavily relied upon and relayed immediately to all affected counties upon receipt. PEMA has no meteorologists on staff but, they do place pro-active "wake-up calls" to county EOC's as either severe thunderstorms or flash flooding situations are monitored on radar to approach the county. Additionally value-added QPF's and basin warnings are issued by their private meteorological service which are relayed to the county EOC's. In 90% of flash flood warnings only NWS products are disseminated.

16. **What are the legal implications of the services provided?**
Since a legislated mandate exists the only legal implication exists if they do not relay the NWS warnings to a county. This problem has never occurred nor are they concerned that it will. The PEMA system will continue because of the legislated mandate.

17. **Has the systems been tested by recent flooding situation?** The system was severely tested and "failed" the 1990 Shadyside Flash Flood. This flash flood prompted them to add radar monitoring capabilities and the private meteorologists to supplement NWS products. Since then numerous severe winter storms and severe weather episodes have been successfully monitored and warned by the system.

18. **How has it performed? "Very well thank you."**

19. **Are there alternative uses of your system which help justify its existence and funding?** As earlier indicated the system doubles as a communications system for the State Highway patrol, State Public Works and local law enforcement communities. These uses have helped to justify the network as did the Three Mile Island nuclear hazmet problem 10 years ago. No educational use is made of the system but they were very interested in the Oklahoma experience and were planning to follow up on expanded alternative uses.

ASSESSMENT OF OUT-OF-STATE FLOOD WARNING SYSTEM

Name of Flood warning System: Urban Drainage & Flood Control District of Denver, Colorado Flash Flood Prediction Program (F2P2)

Location of FWS: 6 county Denver, Colorado metro area, approximately 1700 square miles. Operations center in Denver at 2480 W. 26th Avenue, Suite 310B, Denver, CO 80211, (303)-458-1464.

Key Contacts: Kevin Stewart

1. **What is the physical configuration of the system? The F2P2** embodies a 5 month 15 April to 15 September operations season as an active FWS but maintains a 12 month flood detection network (FDN). Pro-active flash flood potential is predicted and monitored by a private meteorological service (PMS) for the District. A FDN and basin flood warning plan is enacted with interested communities who perform a 50/50 cost-share installation to install a FDN which is ten maintained by the District.

2. **What is the basic design of the system? The** PMS maintains a 24 hour metwatch of the District during the operations season and prepares daily Heavy Precipitation Outlooks (HPO) which include a county quantitative precipitation forecast (QPF), probability of occurrence and prime time for precipitation threat. The PMS has a FDN base station and receives all basin FDN data, maintains a satellite live line through a NIDS vendor to the Front Range Doppler (FTG) maintained by the NWS and selected NWS satellite products, and maintains its own weather operations center staffed by 1-3 meteorologists, a met-tech and communications expert.

3. **What is the motivation and source of the system?** The deadly and devastating Big Thompson Flash Flood of 1976 which killed 139 people in nearby Larimer County acted as the focal point for the 1979 start of the F2P2.

4. **What was the installation procedure? The FWS consists of both the F2P2 at the PMS and FDN installed in selected high hazard basins.** The District has an installation and maintenance contract with DIAD, Inc of Boulder for the FDN's. The affected jurisdiction performs a 50/50 cost share with the District to fund installation and the District picks up further maintenance costs.

5. **What types of data are used as input to the system?** Outside of the fully equipped PMS, the F2P2 receives ALERT raingauge, stream gauge and weather station data via radio/transponder relays to the home base stations. A 22 station MESONET of automated weather stations is accessed by telephone to assist in flash flood potential assessment and Doppler radar is used to issue specific warnings.

Weather: The District receives all NWS and PMS flash flood and severe weather products. The PMS receives via satellite NOAA Domestic line upper air and surface observations and NWS forecast discussions, NOAA DIFAX NWS numerical surface and upper air analyses and predictions. The District maintains and receives data from 4 weather stations in Boulder County, 2 in Jefferson County, 1 in Denver County and 1 in Araraphoe County.

Precipitation: 136 ALERT rain gages

Hydrological: 23 ALERT stream gages

Communications: Products are transmitted by telephone, normal fax and USWEST Broadcast Fax. Ham radio networks are used as back-up during severe weather.

6. **Decision-making - do you issue internal warnings?:** Yes see attached papers for details. **When a potential for flash flooding exists at pre-determined criteria level an internal alert is issued. The alert or Message 1 is sent by fax with phone back-up to the designated FDN or county communications center for further relay. If the NWS issues a flash flood watch or the PMS indicates a similar threat level a Message 2 is sent. Similarly if a flash food threat is imminent or occurring or the NWS issues a flash flood warning a Message 3 is issued by the PMS. The PMS prepares basin-specific QPFs and issues stormtracks for all thunderstorm systems with flash flooding potential that cross the District. See attachments. This FWS is the most pro-active in the country!!!!!**

7. **What types of users do you support?** The primary users are the 6 counties and 43 cities in the District with designated contacts within each FDN with a flood warning plan. The emergency response community is the primary user.

8. **What types of products does the system prepare routinely?** The PMS prepares a daily Heavy Precipitation Outlook, basin specific quantitative precipitation forecasts, storm track predictions and internal MESSAGE statements. The District electronic bulletin board collects and additionally re-transmits these products to both other base stations or call-in modem transfer to F2P2 users.

9. **Do you have a budget cost analysis for the FWS?** yes.

Development:

Installation: To date the cost of FDN installation has been $1.1 million
Operation: Internal District budgets are about $250,000 annually. The 16 year cost of the F2P2 PMS has been about $675,000.

Maintenance: About $60,000 annually and about $750,000 since 1983.
Training: Hard to estimate.
FTE's: 1 at the District, 3 at the PMS for 5 months, 1 for maintenance.

10. **What is the basic funding source for the FWS ?** Legislated utility bill tax.

11. **How often is the FWS used to support flooding support decision-making?** About 43 days each season flash flood potential exists and the program is activated to high support levels.

12. **What is the user satisfaction level?** Surveyed user support is very high!!

13. **What is your systems operations satisfaction level?** Very high but always trying to improve communications, forecast and training support. Individual county contacts must improve their level of participation.

14. **If you were starting over what would you do differently?** Nothing.

15. **Do you prepare or do you have flood warning responsibilities?** Yes, the PMS can issue both flash flood watches or flash flood warnings. Close communications with the local NWS WFO is maintained so joint warnings can be issued. EOC support comes first.

16. **What are the legal implications of the services provided?** Weather is an act of God and anything we do to inform our users of its intentions is a service. No liability save negligence on the part of the PMS or maintenance company. In 16 years of operations no problems have been encountered.

17. **Has the systems been tested by recent flooding situation?** no, other than 20-30 episodes of nuisance street and stream flooding which have all been predicted.

18. **How has it performed?** All events have been forecasted with a 30-90 minute lead-time and a flash alarm rate of less than 20%.

19. **Are there alternative uses of your system which help justify its existence and funding?** Additional support is given by the PMS to county/city EOC's during forest fires, HAZMET situations, city fires, severe weather events, rescue operations in the mountains of Boulder and Jefferson County, pollution and high wind situations. Significant use of the system is made by related hydrologic and construction programs of the District.

ASSESSMENT OF OUT-OF-STATE FLOOD WARNING SYSTEM

Name of Flood warning System: Harris County Flood Control District Flood Warning System

Location of FWS: Harris County Flood Control District, 9900 Northwest Freeway, Suite 220, Houston, Texas 77092, (713)-684-4000

Key Contacts: Gary Stobb, Director of Operations, Jim White

1. **What is the physical configuration of the system?** The system is composed of 76 ALERT rain and stream gauges and four weather stations in Harris County, Texas designed to detect flooding on major streams and rivers.

2. **What is the basic design of the system?**

3. **What is the motivation and source of the system?** Repeated flooding due to heavy thunderstorm and occasional hurricane or tropical rainfall.

4. **What was the installation procedure?** Entire FWS was installed by the Flood Control District personnel.

5. **What types of data are used as input to the system?**

   Weather: Four weather stations provide local input. A private value-added vendor provides access to local radar and satellite and NWS forecasts via a dial-up modem data exchange program.

   Precipitation: 76 combination rain/stream gauges

   Hydrological: see above plus the NWS maintains a HEC-1 basin specific model which is run in heavy storm situations.

   Communications: All ALERT data is received via radio with telephone communication a significant link. Internal use of radio between Harris County offices is heavy and important due to telephone down-time during flooding. This aspect of program still is a weak link.

6. **Decision-making - do you issue internal warnings?:** No NWS issues all warnings and is the only word used unless common sense dictates actions are needed.

7. **What types of users do you support?** Equal support to public and local Harris County agencies. HCFWS is unique in country in that it has close ties with the media

and "broadcasts" directly to the public all NWS and local flooding information. Additional public support is rendered on the phone. Recent experiences and budget cut-backs are causing a re-focus from direct public support to more media support to reach public. Additionally phone support to public is decreasing as phone support to local agencies is increasing.

8. **What types of products does the system prepare routinely?** All standard ALERT base station products plus direct public information on flooding over radio and TV.

9. **Do you have a budget cost analysis for the FWS?**

   Development:
   Installation: $550,000 for the basic system
   Operation: $250,000 per year operations and maintenance
   Maintenance:
   Training: Very little
   FTE's: 3 operational FTE's and 2 maintenance FTE's

10. **What is the basic funding source for the FWS ?** Tax-based on Harris County property with a fixed budget.

11. **How often is the FWS used to support flooding support decision-making?** The system is tested annually. Biggest problems are heavy sustained rainfall from tropical weather systems moving in off the Gulf of Mexico.

12. **What is the user satisfaction level?** Communications with internal county users could be improved and will receive additional attention as the focus on public support shifts to use of the media. More time to support internal users will be freed by this practice.

13. **What is your systems operations satisfaction level?** Reasonable but will improve after the communications with users are resolved. Internal power struggles within supported agencies has been part of the problem which will settle out.

14. **If you were starting over what would you do differently?**
    Merge Harris County Office of Emergency Management into the Harris County Flood Control District, create separate Harris County Flood Warning department by moving it out of the flood control district, clear funding paths and create the opportunity for program funding growth and policy decisions and make the program autonomous with no political ties. Additionally we would improve NWS flood warning capabilities by adding either internal forecast capability or value-added vendor forecasts, add staff engineer to run operationally a HEC-1 model, acquire real-time radar drop and provide internal forecasts but only advisory in nature.

15. **Do you prepare or do you have flood warning responsibilities?**

    NONE use only NWS. On rare occasion have issued internal warnings or public warnings before NWS because they were obviously needed.

16. **What are the legal implications of the services provided?** None because they were advisory in nature.

17. **Has the systems been tested by recent flooding situation?**
    The weekend after the SAAS conference record flooding affected Harris County and nearby Beaumont area. Over 20-30 inches of rain inundated the region. The problems discussed in this interview were still very present but overall the system responded with good public support and adequate agency support. Most HCFCD personnel were stretched beyond limits by this storm episode and refrained from further comment due to the added stress. Missions are still being reviewed and revised.

18. **How has it performed?** See above.

19. **Are there alternative uses of your system which help justify its existence and funding?** Except for NPDES mandated monitoring responsibilities the other alternative uses are not mandated nor do they assist in the funding patterns.

ASSESSMENT OF OUT-OF-STATE FLOOD WARNING SYSTEM

Name of Flood warning System: City of Austin, Texas Flood Early Warning System

Location of FWS: Department of Public Works and Transportation, Stormwater management Div., One Texas Center, 505 Barton Springs Rd., Suite 980, P.O. Box 1088, Austin Texas, (512)-499-7108

Key Contacts: Andy Rooke, Flood Early Warning System Manager

1. **What is the physical configuration of the system?**The Austin EFWS is composed of 85 Rain Gauges of which 66 are combination rain and stream gauges and 4 weather stations.

2. **What is the basic design of the system?** The system is design to provide 30-90 minutes lead-time for thunderstorm produced flash flooding on the main streams and river which flow across the populated Austin metro area.

3. **What is the motivation and source of the system?** The motivation was provided by devastating flooding which occurred in 1981. The city council approved the need for a FWS and has provided funding since 1981.

4. **What was the installation procedure?** The installation of the systems began in 1986 and was completed 6 years later. improvements are considered annually and approved as needed.

5. **What types of data are used as input to the system?**
   Standard ALERT based FWS with no special inputs.
   Weather:
   4 ALERT weather stations not used except by NWS and for EPA related alternative uses.
   Precipitation: 85 ALERT gauges

   Hydrological: 66 stream gauges

   Communications: All ALERT information is sent to two base stations (redundancy) with pager call up system once warnings activated.

6. **Decision-making - do you issue internal warnings?:** The NWS provides the primary warning input as the AEFWS does not have a warning mandate within its program. However, the AFWS does issue "unofficial warnings" to emergency

response agencies when the NWS is slow to issue a warning an it is needed to activate evacuations.

7. **What types of users do you support?** The Fire, Police and Public Works emergency response units are the only agencies directly supported.

8. **What types of products does the system prepare routinely?** Standard ALERT base station products and internal ALERT-based flash flooding advice to ERT.

9. **Do you have a budget cost analysis for the FWS?**

   Development:
   Installation: Approximately $750,000 with $660,000 in two years beginning 1986.
   Operation: $50,000 per year operations and maintenance
   Maintenance:
   Training: no training budget or program but is being designed.
   FTE's: 3 operations FTE's and 2 maintenance FTE's

10. **What is the basic funding source for the FWS ?** City-approved electric utility tax is the primary funding mechanism. It was approved by city council in 1981 but not used until 1986.

11. **How often is the FWS used to support flooding support decision-making?** The AEFWS receives what seems like annual tests in the form of thunderstorm flash flooding usually between the hours of 3:00AM - 5:00AM when the population is asleep.

12. **What is the user satisfaction level?** Mostly favorable but the usual lead-time have dwindled to 20 minutes or less from the FWS and NWS with a high flash flood watch false alarm rate contributing to a lack of confidence at this time.

13. **What is your systems operations satisfaction level?** Relatively high but we are still discovering which areas in the city have flooding problems based on a particular set of circumstances.

14. **If you were starting over what would you do differently?** Convince the users and city council that you can't rely on technology alone to provide an warning. Would add a forecast component to the program to supplement NWS with user-focused products relevant to the FWS. They will be adding a NIDS provided drop on the local doppler radar in the next year to help them get more warning time. Additionally would conduct a thorough on-going study to identify where flooding problems can occur within the city under what conditions.

15. **Do you prepare or do you have flood warning responsibilities?**
The program mandate does not call for user-generated warnings. The NWS maintains a close relationship to the program but has have problems providing a reliable forecast due to lack of effective forecast techniques not a lack of effort on the part of the NWS. New WSR-88D will help but the lead-time issue - less than 30 minutes in most cases - is still a very hot topic. The FWS will issue unofficial warnings to emergency response teams and the public as needed.

16. **What are the legal implications of the services provided?**
NONE! If the services were not provided then they would face a legal problem of not using available resources to help the public.

17. **Has the systems been tested by recent flooding situation?** The system is regularly tested and faced a 9" rain in 3 hours on October 8/9, 1994 the week before the SAAS conference. The storm produced severe flash flooding during the late night hours and 20 rescues of people were accomplished with no loss of life. Lead-time was less than 20 minutes again and it occurred on a low staffed Friday night early Saturday morning time period. The public was not alerted by the NWS 1000PM news but Andy "knew" from experience that a problem was brewing. He has a personal computer at home to monitor the ALERT systems and could tell from rainfall observations and the frequency of lightning that problems were close at hand. He initiated the warnings in this case and helped with the rescue efforts by providing information.

18. **How has it performed?** Okay but needs to develop more lead-time.

19. **Are there alternative uses of your system which help justify its existence and funding?** Yes, EPA water quality monitoring uses 25 of the ALERT sites to gather data. The rainfall data is used for earthen dam safety and irrigation considerations. The archived data base is used for local studies and legal cases. During the summer the rainfall data helps with local recreational irrigation and water supply issues.

ASSESSMENT OF OUT-OF-STATE FLOOD WARNING SYSTEM

Name of Flood warning System: City of Tulsa, Oklahoma Flood warning System.

Location of FWS: Division of Public Works, Office of Emergency Management 200 Civic Center, Tulsa, Oklahoma 74103, (918)-596-1846

Key Contacts: Jack Sheridan, Manager, Office of Emergency Management and Jack Page, Manager, Development Services

1. **What is the physical configuration of the system?** The FWS has been designed to afford a 1-2 hour lead-time for the City of Tulsa from stream and river flooding.

2. **What is the basic design of the system?** The basic design relies on 37 rain gauges and 17 stream gauges in selected basins across the upstream and in-city areas. two base stations are maintained, one in Public Works at OEM and the other at NWS forecast office.

3. **What is the motivation and source of the system?** Serious flooding has plagued the city and the FWS was established in response to severe flooding episodes experienced during the early 1980's. Unfortunately the FWS has served more as a flood detection network and has not afforded the lead-time desired.

4. **What was the installation procedure?** Vendor-installed.

5. **What types of data are used as input to the system?**

   Weather: No weather stations exist in network at this time.

   Precipitation: 37 ALERT gauges plus private value-added vendor supply of NWS radar and forecast information via a modem/base station interaction with Weather Service International.

   Hydrological: 17 stream gauges

   Communications: Normal ALERT radio communication for data and telephone and fax for internal communications are used.

6. **Decision-making - do you issue internal warnings?:** No the NWS supplies all warnings but occasional as "needed advice" is offered concerning evacuations and rescue if NWS is slow to issue.

7. **What types of users do you support?** Support is solely offered to city departments including Public Works, Fire and Police.

8. **What types of products does the system prepare routinely?**
Standard enhanced ALERT base station displays of observed data.

9. **Do you have a budget cost analysis for the FWS?**

Development: None
Installation: Estimated cost of the systems as it stands is approximately $500,000.
Operation: About $18,000 per year not including salaries to obtain private value-added vendor weather data.
Maintenance: N/A
Training: N/A
FTE's: 0.75 operations FTE and 1.5 maintenance FTE's

10. **What is the basic funding source for the FWS ?** City utility tax.

11. **How often is the FWS used to support flooding support decision-making?**
Annually. Most recent case was 4-5"/45 min flash flood from thunderstorms on night of July 14/15, 1994.

12. **What is the user satisfaction level? Very high!!!**

13. **What is your systems operations satisfaction level?** Do not like the NWS over-used watch/warning program for rainfalls that are less than 3.00 " locally. Urban Street and Small Stream Advisories would be sufficient but suffer from federal/Oklahoma flash flood "inflation" factors. NWS has "false-alarmed" local program to death as far as user confidence.

14. **If you were starting over what would you do differently?**
Nothing.

15. **Do you prepare or do you have flood warning responsibilities?**
No all flood warnings are officially issued by the NWS but "unofficially" advice is offered to all city agencies as requested. Some advice contains the same information as a warning.

16. **What are the legal implications of the services provided? NONE**

17. **Has the systems been tested by recent flooding situation?** Yes on the day of the visit thunderstorm street flooding occurred without NWS prediction but the ALERT flood detection system providing sufficient information to allow good decisions to be made.

18. **How has it performed? Very well.**

19. **Are there alternative uses of your system which help justify its existence and funding? None tied directly to funding.** NPDES monitoring is a big user as are local attorneys and water system designers. Water supply issues are supported indirectly as are recreational activities supported by the city.

ASSESSMENT OF OUT-OF-STATE FLOOD WARNING SYSTEM

Name of Flood warning System: City of Dallas River Levee Operations

Location of FWS: City of Dallas, Texas River Levee Operations, 2255 Irving Boulevard, Dallas, Texas 75207

Key Contacts: Ron Shindoll and Steve White

1. **What is the physical configuration of the system?** Two systems are operative in Dallas, one to monitor the Trinity River and associated river flooding ; the other network monitors small urban stream and street flooding problems in Dallas.

2. **What is the basic design of the system?** The system is designed around an elaborate monitoring network and display at the Levee Operations center. 48 sensor sites are included in the network.

3. **What is the motivation and source of the system?** Serious historical Trinity River flooding of the Dallas downtown and residential areas.

4. **What was the installation procedure?** Vendor installed.

5. **What types of data are used as input to the system?**

   Weather: Three weather stations are monitored mainly by the NWS. Vendor supplied radar and weather forecast data from NWS are used for support but NWS is the primary source.

   Precipitation: 46 ALERT raingauges

   Hydrological: 12 stream gauges

   Communications: Usual ALERT radio, internal police radio, telephone and fax

6. **Decision-making - do you issue internal warnings?: No** NWS has the warning mandate in the program but will assume pro-active stance if NWS drops the ball and issue "unofficial statements of advice".

7. **What types of users do you support?** Internal emergency response units, police and fire and public works.

8. **What types of products does the system prepare routinely?** Normal enhanced ALERT base station displays.

9. **Do you have a budget cost analysis for the FWS?**

Development: $450,000
Installation:
Operation: estimated at $220,000 per year.
Maintenance: N/A
Training:N/A
FTE's: 5 operations, 1 maintenance

10. **What is the basic funding source for the FWS ?** Utility tax and property tax.

11. **How often is the FWS used to support flooding support decision-making?** Several times per season.

12. **What is the user satisfaction level?** Poor lead-times for city/urban flooding are driving the users and operators to a level of dissatisfaction. These problems are weather forecast related.

13. **What is your systems operations satisfaction level?** Want better forecast support from NWS or will hire value-added private weather support.

14. **If you were starting over what would you do differently?** Nothing, except enhance the weather forecast support component of the program by adding value-added private weather support.

15. **Do you prepare or do you have flood warning responsibilities? see above**

16. **What are the legal implications of the services provided?NONE**

17. **Has the systems been tested by recent flooding situation? Yes.** Dallas was tested with an unforecast thunderstorm flash flood the first week of October which dropped 6 inches of rain in less than 60 minutes and caught the city unprepared during a Friday rush hour. This event has prompted an active push on the FWS part to obtain better weather forecast support in the form of QPF's and Stormtracks and radar display.

18. **How has it performed?** River flooding on the Trinity River is handled and sensed very well but urban and small stream and street flooding is handled poorly because of the rapid response time of the local streams. Once the flooding rainfalls detected the flooding that is already occurring.

19. **Are there alternative uses of your system which help justify its existence and funding? Water related activities and river operations plus the usual EPA mandated NPDES activities and city river recreation and water supply issues.**

ASSESSMENT OF OUT-OF-STATE FLOOD WARNING SYSTEM

Name of Flood warning System: Pikes Peak Flash Flood Warning System

Location of FWS: Regional Building Dept. 101 West Costilla, Colorado Springs, CO 80903, (719)-578-6802

Key Contacts: Dan Bunting, Regional Floodplains Administrator

1. **What is the physical configuration of the system?** System is mainly a re-active flood detection network which has a population of 25,000 and 10,000 building in floodplains which could and do flash flood. It depends heavily on NWS flash flood watch/warning statements and flood observation to produce evacuations.

2. **What is the basic design of the system?** The system includes 46 rain gauges, 6 weather stations with rain gauges and 6 stream gauges with 5 base stations at:NWS airport office, Pueblo Fire Department, Colorado Springs Fire Dept., County OEM and the Pikes Peak FWS manager's office (Dan's location).

3. **What is the motivation and source of the system?** The motivation for the FWS came from a 1986 Flood Symposium held in Colorado Springs to address the flooding hazards and risks in the El Paso County area. A recommendation from the Flood Hazard Task Force for the installation of the system was the key source of the programs initiation.

4. **What was the installation procedure?** The program started win 1986 with a 26 rain gauge and 1 base operation and has grown into the expanded 46 rain gauge and 5 base station FWS of today.

5. **What types of data are used as input to the system?**

   Weather: The FWS runs 5 weather stations but their input is rarely used. No weather data is analyzed within the program except by the NWS but 38 NOAA Weather Wire Products for El Paso County ar sent to the FWS center base station..

   Precipitation: Rainfall data from the 46 rain gauges comprises the entire rainfall input into the program.

   Hydrological: Five stream gauges are used to monitor flow on Fountain Creek, Jimmy Camp Creek and Sand Creek.

   Communications: All rainfall and streaflow data is communicated using ALERT radio protocol and telephone/ Pacquet radio is used to communicate between base stations.

6. **Decision-making - do you issue internal warnings?:** No the NWS issues all warnings and the FWS reacts to them as best as possible. If a warning is needed and none has been issued by the NWS Dan Bunting has issued "unofficial warnings and evacuations" based on FDN observation. These warnings are not used to support the public directly but are sent to emergency response agencies. Dan Bunting sets the base station alarm levels (0.15"/15 min and 0.50"/30 min) and he reacts to the alarms despite the fact that basin response times are less than 30 minutes in most cases.

7. **What types of users do you support?** The primary users of the system are emergency response organizations within El Paso and Pueblo Counties. There are 10 primary contact points within the agencies earlier identified. The cities of Colorado Springs, Manitou Springs, Fountain, Greeen Mountain Falls and Palmer Lake are supported in El Paso County while Pueblo is supported in Pueblo County.

8. **What types of products does the system prepare routinely?** Thje standard Enhanced ALERT Users menu of display products for an ALERT system are supported.

9. **Do you have a budget cost analysis for the FWS?**

   Development: Development and installation cost $500,000 approximately
   Installation: see above
   Operation: Annual operations budget costs approximately$19,000/yr
   Maintenance:$150/yr/site or $7,000/yr
   Training: Eight to 10 organizations receive a 2 hour training session from Dan annually.
   FTE's: 0.50 FTE operations, 0.25 FTE maintenance

10. **What is the basic funding source for the FWS ?**Budget funds paid annaully by the five cities in the program based on per cent of population at risk.

11. **How often is the FWS used to support flooding support decision-making?** Annual exposure to as erious flood occurs from April to September. Usually 25-30 days a season the FWS is exposed to a flash flood potential.

12. **What is the user satisfaction level?** Very average as the FWS has had limited success in providing leadtime or response time to the agencies participating in the FWS.

13. **What is your systems operations satisfaction level?** It is under manned and underfunds but we'll do the best that we can to serve the citizens and organizations with our limited budget.

14. **If you were starting over what would you do differently?**
Have more money and inter-organization support. The program is somewhat disjointed and does not receive the sponsorship form all agencies that it deserves. The ability to afford direct weather support and receive real-time radar data was advocated.

15. **Do you prepare or do you have flood warning responsibilities?**
NO the program relies on the NWS is issue flash flood watches and warnings. On occasion Dan will issu " unofficial warnings or order evacuations" when the NWS is too slow to react or Mother Nature was particularly nasty.

16. **What are the legal implications of the services provided?** NONE

17. **Has the systems been tested by recent flooding situation?** Yes. The FWS faced a 4-6 inch in 45 minute flash flood over Jimmy Camp Creek and Fountain Creek on September 2, 1994. No Leatime was afforded to emergecny response teams and the street floding almost claimed several lives. !@ inche sof large hail accomp[naied the hail to produce a very nasty situation.

18. **How has it performed?** The FWS fails to warn with adequate leadtime but always detects the problem as its happening.

19. **Are there alternative uses of your system which help justify its existence and funding?** Weather data is used for utility estimates, air pollution monitoring, water quality programs, forest fire weather, dam safety and water supply uses.

Out-of State Interviews: Federal Agencies

Fourth National Heavy Precipitation Workshop, Scottsdale AZ September 12-16,1994.

This workshop was attended in lieu of traveling to National Weather Service Headquarters in Silver Spring, Maryland and NWS Western Region Headquarters in Salt Lake City, Utah. A copy of the program is attached and brief interview excerpts are included below as they pertain to the Arizona Statewide Network:

National Severe Storms Laboratory - Norman, OK

Ken Howard/Daryl McCollum(NSSL): They commented on the problems of using the Phoenix WSR-88D radar in the combined desert and mountainous areas in central Arizona. At present caution is advised in accepting precipitation related products due to significant, non-repeatable errors in rainfall estimate noted during summer 1994.

Tim O'Bannon: WSR-88D rainfall estimates are affected in Phoenix by the dry desert climate however of more concern are the repeated over- and under-estimates which were observed during the past monsoon seasons when "dry boundary layer conditions and effects were not present". These problems appear to be more of the same problems noted across the US with the precipitation products. These comments were echoed by **Mike Eilts** and **Doug Greene** in their separate papers on the Phoenix WSR-88D.

Ron Holle: He noted that very lightning active thunderstorms in southern Arizona were related to basin specific heavy rainfalls in some cases. He did not offer any new techniques but appealed for more research work on the problem.

NWS Techniques Development Laboratory - Camp Springs, MD.

Dave Kitzmiller: He noted that short range quantitative precipitation forecasts (QPF) were not likely to improve quickly especially in the western states. The use of an extrapolation and statistical technique showing promise in the eastern states does not appear transferable to the west just yet.

Rod Scoefield: He was very emphatic in declaring that the newly launched GOES-8 would produce new techniques in satellite precipitation estimates including in the western US> He noted that current over-/under- estimates were related to atmospheric structure variations which have no been included in current estimation techniques but could be with the new satellite. We hope he is right and we see the results in 2-4 years.

Bruce Terry: Indicated that thunderstorm flash flooding rainfall predictions were and may continue to be a very vexing forecast problem for the nest 3-5 years unless new visions or techniques are developed.

Dave Olsen: Indicated that the NMC Weather Forecast Branch modernization should allow more computer resources to focus on the prediction of QPF from larger scale weather systems in the next 1-3 years. Right now the problem is continually a trouble spot with no apparent solutions.

River Forecast Centers - (RFC)

Theresa Drake: The Pittsburgh WFO and RFC have developed a fairly successful improvement in river forecasting using a form of operationally significant probabilistic QPF's. The techniques show that the river forecasts were much better, available earlier and more reliable when they used both observational and QPF precipitation information.

Bill Lawrence: The Arkansas-Red River RFC in Tulsa is the NWS' state-of-the-art RFC of the future. I visited with Bill and learned that they are about 100 times more powerful with their computing capability than the current RFC including the Colorado River Basin RFC in Salt Lake City. Bill acknowledged that the current NWS QPF both manual and computer sourced leave too much to be desired to have positive impacts on current river forecasts. He did mention that the improved observational estimation by radar of aerial rainfall was producing significant improvement in HEC-1 and other river basin scale forecast models,. He expects this improvement nationally in 2-4 years.

Andy Morin: He acknowledged the positive impact that mesonet data in California had on both basin river flow models and short range streamflow forecasts.

Western Region Headquarters

Tom Potter: Tom is regional NWS director and he whole-heartedly endorsed the Arizona Statewide Network's concept and plan. He indicated that the NWS will play as active a role as possible through the CRB RFC and the Phoenix/Tucson RFC's. He was very complimentary of the Arizona WFO's and their managers. He acknowledged the unique situation between the Salt River Project, NSSL and NWS. He felt that this relationship would be a big plus for the state and would insure that improvements in short range forecasting in the west would be enjoyed first in Arizona.

BobTibi: Bob is lead hydrologist for the NWS Western Region and noted that the use of WSR-88D precipitation products however flawed they may be would be a big improvement over the use of few observations now available. He agreed that the use of ALERT rainfall data to "ground truth" the WSR-88D radar rainfall products could improve the products. He encouraged the development of the Statewide Network and looked forward to it becoming an "Oklahoma-like" network.

APPENDIX D

IN-STATE INTERVIEW SUMMARY REPORTS

IN-STATE INTERVIEW SUMMARY REPORTS

As described in the Final Report, the project team interviewed Tier 1 and Tier 2 providers and users of hydrometerological data within Arizona. The interview summary reports prepared for each agency are contained in this Appendix D. A consistent reporting format was used to facilitate comparison between agencies. The content of the interviews was categorized into four main subject areas: responsibilities, resources, capabilities, and needs.

To ensure accuracy in reporting on the information provided by all agencies in their interviews, the project team provided the draft interview summary report of their interview to each interviewee for review, comment and/or additions. Interview summary reports for each agency were then finalized based upon the feedback received from the interviewee.

Interview List

Tier 1

Network Committee

Flood Control District of Maricopa County
Arizona Department of Water Resources
Salt River Project
Pima County Flood Control District
US Geological Survey
US Bureau of Reclamation
National Weather Service (Phoenix NWSFO)
US Army Corps of Engineers (Phoenix)
Central Arizona Water Conservation District
Arizona Division of Emergency Management
State Climatologist for Arizona

Tier 2

Federal Agencies

US Army Corps of Engineers (Los Angeles)
Bureau of Indian Affairs

State Agencies

Arizona State Parks
Arizona Department of Transportation - Traffic Operations Center

Counties

Maricopa County Department of Transportation
Maricopa County Department of Emergency Management
Maricopa County Sheriff's Office
Yuma County Public Works Director
Santa Cruz County Floodplain Administrator
Cochise County Highway Floodplain Department
Graham County Engineer
Greenlee County Engineer/Public Works Director
La Paz County Director of Community Development
Mohave County Director of Emergency Services/Flood Control
Coconino County Floodplain Administrator
Yavapai County Flood Control District
Gila County Director of Emergency Services
Apache County Development and Community Service
Navajo County Public Works Director
Pinal County Flood Control Engineer

Municipalities
City of Phoenix
City of Tucson Department of Transportation Engineering Division
City of Scottsdale Emergency Management
City of Peoria Fire Department

Rural Communities
Bullhead City Community Development Services
Clifton Town Manager
Duncan Emergency Services

Tier 1 Agency Interview Reports

Flood Control District of Maricopa County
Arizona Department of Water Resources
Salt River Project
Pima County Flood Control District
US Geological Survey
US Bureau of Reclamation
National Weather Service (Phoenix NWSFO)
US Army Corps of Engineers (Phoenix)
Central Arizona Water Conservation District
Arizona Division of Emergency Management
State Climatologist for Arizona

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Interview Summary Outline

RESPONSIBILITIES	RESOURCES	CAPABILITIES	NEEDS
MISSION • Infrastructure - Equipment - Personnel • Operational Functions - Flood warning - Programming support - Develop new products **FLOOD WARNINGS** • County Agencies • Basin-Specific Flood Warning Plans	**EQUIPMENT** • ALERT System • Base Stations - Alarm functions - Data Storing - Decision support functions **PERSONNEL** • FCDMC Staff • Observer Network **FUNDING SOURCES** • Property Tax - Operating budget - Capital Improvement Plans	**DATA GENERATED** • Rain • Stage • Weather **PROGRAMMING SUPPORT** • Base Station Programming - Special displays - Expert Systems • Basin Specific Flood Warning Plans **FLOOD FORECASTING** • HEC-1F Project **ALTERNATIVE USES**	**DATA NEEDS/PROBLEMS** **DESIRED PRODUCTS** • Standard Image Product • Narrative Weather Reports • Predictive Hydrographs • Basin-Specific Products - QPF by basin - Storm track map - Soil moisture maps - HEC-1 templates

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Summary of Interview with Steve Waters, Hydrologist on 30 August 1994

RESPONSIBILITIES

MISSION

The mission is to design, install and maintain an accurate, reliable, real-time flood detection and data collection system. The system is operated and maintained for: 1) monitoring 35 flood control structures and projects and their contributing watersheds, impoundment areas, outlets, and channel stages; 2) flood detection and evacuations, and; 3) storm monitoring and data collection for storm reports, model calibration and formulation of a database for arid west precipitation and streamflow events.

- **Infrastructure**
  It is part of the mission to provide the necessary equipment and personnel within Maricopa County to perform the flood data collection function. In doing this, the FCDMC works with other agencies in the state to develop new capabilities and cooperative agreements. This may either be done directly or on a cost sharing basis. Once the equipment is installed, the local agencies may contact with the FCDMC to provide maintenance.

- **Operational Functions**
  Besides this infrastructure mission, there is a significant operational responsibility to provide flood information to other county agencies and for several local communities. Most of the work of the FCDMC is done before a flood occurs. During an actual event, the majority of the action shifts to local emergency response agencies. The District provides advice, communication support and an overview of the big picture.

  - **Flood Warning**
    During a flood emergency, the FCDMC will dispatch District crews to monitor stage at various flood retarding structures, watch streams, or pump detention basins as required. The District is responsible for providing information to other county agencies and several local communities.

  - **Provide setup and programming support**
    As part of the infrastructure for flood warning, the FCDMC will work to get base stations properly set up with decision support displays and will work with local agencies to develop staged flood alert plans.

  - **Develop new products in conjunction with other agencies**
    The FCDMC is perhaps at the lowest organizational level where there are resources to maintain a staff whose primary function is flood control. Thus, the FCDMC is able to work with others throughout the state to keep abreast of the latest developments in current technology and decide what products would be useful for Maricopa County.

FLOOD WARNING

The District is responsible for warning the Maricopa County Department of Transportation (MCDOT) so that it may initiate appropriate emergency response actions. In the future, FCDMC will drop warning responsibility for MCDOT as that agency becomes capable of acquiring information on a dial-in basis from the Districts base station.

In the future, three local areas will be warned directly by FCDMC. These areas are Wickenburg, Fountain Hills, and Castle Creek. The warnings will trigger implementation of basin-specific flood warning plans soon to be developed jointly by the District and the affected local communities. Future flood warning responsibilities may expand to include other areas.

RESOURCES

EQUIPMENT

- **ALERT System**
  The ALERT System is an automated gage network comprised of 160 telemetry rain gages and 65 telemetry stream gages located primarily in Maricopa County with additional gauges in Yavapai, Pinal, Gila, and La Paz Counties. Weather data is collected at 10 stations.

  This real-time data is shared with the National Weather Service which uses the information when issuing flash flood warnings and other weather advisories.

- **Base Stations**
  Base stations receive data from the gauges and weather stations in the field. They store this data and provide a dial-in bulletin board so that other computers may read their data.

  - **Alarm functions**
    It is possible to set alarm levels for any of the gauges in the system so that the base station alerts the user that there is a potential problem. When an alarm condition is received by the base station, the station may be programmed to automatically telephone key people and inform them of the situation.

  - **Data storing**
    Base stations may both back up and archive observations from the gauges that report to them. Backup is an operational store that allows working records to be reconstituted in the event of a disk crash. Archiving is the permanent storing of observation data that has been quality checked.

  - **Decision support functions**
    In addition to the data store and alarm functions of the base stations, they can be programmed to provide decision support tools to the users of the system.

- **Expert system**
  The expert system feature of the base station software allows more complex conditions to be programmed for generating alerts and advising actions. For example, if precipitation in combination with a certain level in a detention structure indicates that there will be problems at some other point shortly, the expert system can be set up to notify the operator when that set of conditions occurs.

- **Special displays**
  Special displays can be constructed that will show a number of critical data in a graphic form on a single screen. For example, it is possible to show real time stage information at a stream gauge by varying the visible fill in a graphic representation of the channel. The same screen might show flow over the past several hours and mark levels that indicate that there will be flooding problems.

PERSONNEL

The FCDMC ALERT program currently has a branch chief, a program coordinator, two hydrologists and seven technicians that are assigned flood warning responsibilities. Of the seven technicians, four install and field repair equipment and perform preventative maintenance on a six month rotation cycle. Two technicians do shop repair and maintenance of equipment and administer the other field technicians. The remaining technician handles gauge permits and manages the District's network of approximately 200 volunteer observers. The observers collect rainfall daily totals and report that data to the FCDMC on a monthly basis.

FUNDING SOURCES

The FCDMC is funded directly through property taxes. Installation of gages and other special needs are funded through approved Capital Improvement Plans. The operational budget of the District funds personnel salaries and equipment maintenance.

CAPABILITIES

DATA GENERATED

The FCDMC ALERT System collects rainfall data and stream gages provide stage information at their locations. Where there is cross section data, stage may be converted to streamflow. Weather stations provide precipitation, temperature, wind direction and speed, and humidity.

PROGRAMMING SUPPORT

- **Base station programming**
  The FCDMC is capable of developing special displays that quickly and concisely provide information to local emergency management agencies relative to the status of the event situation. This is a specialized skill not generally found at the local emergency response agency level.

  Similarly, realizing the potential for added insight and earlier warning by using the expert system capability of the base station software may be beyond the skill of local emergency managers. This service can be provided by the FCDMC.

- **Basin Specific Flood Warning Plans**
  Developing a flood alert plan requires a knowledge of the basin hydrology as well as an assessment of risk. The FCDMC hydrologists are able to model the various basins in their jurisdiction and provide flow and stage information at critical points. The local emergency management agencies provide the information as to the people and property at risk based on that model data.

  The combination of the hydrologic/hydraulic analysis and risk assessment can be used to develop an alert and evacuation plan for each basin. These plans must, of course, be in place before the event and they must be exercised periodically.

FLOOD FORECASTING

A current project of the FCDMC is to develop the capability to forecast the hydrologic response of a basin to an event in progress without the aid of a quantitative precipitation forecast (QPF) where it is reasonable to do so (i.e. enough lead time in basin response exists). This would be accomplished by reading real-time rainfall data into the HEC-IF model to compute basin hydrographs. Streamflow forecasts could then be used to predict stage at critical points of interest where cross-section data is available. This project is in the early stages of development.

ALTERNATIVE USES

The District receives many requests for the rain, stage and weather data collected via the ALERT System from a variety of users. These include attorneys, engineering consultants, insurance companies investigating claims, and water resources researchers. Several users require the data to comply with the National Pollution Discharge Elimination System (NPDES) requirements.

Suggested alternative uses for the data collected as part of the Statewide Network are water budget, rainfall and evaporation studies.

NEEDS

DATA NEEDS/PROBLEMS

The FCDMC currently uses the following NWS forecast products:

- AFOS Text
- AFOS Graphics
- Weather Channel
- PBS AM Weather

Experience with the QPF products has indicated that the text products address locales too far from Maricopa County to be useful. Similarly, the AFOS graphic maps are not site specific enough to meet the Districts needs. More frequent, more specific, more accurate QPF products are needed.

Timely and accurate QPF's could allow time to establish a state of readiness before an event takes place and increase the lead time available for emergency response in flash flood prone areas. This is especially true in the case of summer thunderstorms when the NWS currently issues no QPF's. The Phoenix WSFO would have the local experience necessary to originate QPF's for use in Maricopa County. A daily QPF product would increase the comfort level of the data user.

DESIRED PRODUCTS

- **Standard Image Product**
  A knowledge of the big picture is useful when trying to decide whether to implement emergency response plans. It is impractical to place a radar or satellite feed directly in the local emergency management office. This is because the communications equipment and the computers needed would be prohibitively expensive. Further, such a capability requires a great deal of training in order to quickly analyze what is important. It is unlikely that emergency management organizations have the resources to hire and maintain those skills.

  An alternative which is not so resource intensive would be to have a central site produce composite images and send them to the emergency management agency base stations on a non-interactive basis. Here the central agency meteorologists could select the pictures that would be most useful in keeping field agencies abreast of the situation.

- **Narrative weather reports**
  In conjunction with the above standard image products, it would be useful to have a narrative that explains those images in light of the current atmospheric situation. Since emergency managers are not trained in image interpretation, many would not be sure what actions to take upon seeing an image showing a storm approaching their area. A standard image product supported by a value-added narrative report supplied by a meteorologist who has additional products to interpret would place the manager in a much surer position.

- **Predictive Hydrographs**
  The agencies that operate the impoundments on the major rivers in the state could forecast flows and predict time to peak at various points on those rivers. It would be useful to statewide emergency management agencies to have that information available.

- **Basin-Specific Products**
  - **Quantitative Precipitation Forecast (QPF) by basin**
    QPF in a text format would summarize the outlook for heavy precipitation within a specific basin. The text QPF should contain detailed information as to the percent probability of a basin receiving a specific amount of precipitation for a specific period of time in the future.

    It would be useful to have a graphical QPF to supplement the text QPF. The graphical QPF product needs to be of sufficient detail relative to the boundaries of the specific basin of interest.

- **Storm track map**
  A storm track map would be a useful product for emergency managers to use in implementation basin-specific flood warning plans.

- **Soil moisture maps**
  Runoff is dependent on antecedent soil moisture. A map of the types of soil that are found in a basin would increase the potential accuracy of runoff predictions. If it were possible to keep tract of the amount of moisture in those soils, the results could be even more accurate.

- **HEC-1 templates**
  It may be possible using historic records of rainfall and runoff to calibrate HEC-1 model templates for each basin. As a minimum, two templates might be constructed, one for dry soil and one for saturated soil. When heavy precipitation is forecast, it would be possible to run these templates using the basin QPF to give emergency management agencies advance warning of the range of problems they might expect.

ARIZONA DEPARTMENT OF WATER RESOURCES

Interview Summary Outline

RESPONSIBILITIES

LEGISLATIVE MANDATE (ARS 45:1501-1506)

- Establish Statewide Flood Warning System
  - Coordinate with federal agencies
  - Assist local entities
  - Set statewide policy
- FWS Fund Disbursements
  - Determine eligibility for funding assistance
  - Provide FWS grants to local entities
  - Administer fund
- Provide Technical Assistance

FLOOD WARNING

RESOURCES

FWS FUND

- Develop FWS
- Purchase FWS Equipment
- Provide Assistance to Local Entities
  - Planning
  - Design
  - Installation
  - Operation
  - Maintenance
- Funding Source
  - Legislative appropriations
  - Grants
  - Contributions from other agencies

EQUIPMENT

- Procurement
- Installation
- Training
- Provide Assistance with Maintenance

PERSONNEL

- ADWR FW Staff
- Emergency Operations

CAPABILITIES

DATA COLLECTION

- Statewide ALERT Data
- NEXRAD Special Subscriber Products

TECHNICAL & FINANCIAL ASSISTANCE

- Plan and Design FWS
- Purchase Equipment
- Equipment Installation
- Initial System Operation
  - Hydrologic/hydraulic modeling
  - System calibration

FWS OPERATION & MAINTENANCE

- Technical Training
- Basin-Specific Flood Warning Plans
- Coordinated Exercises
- Equipment Maintenance

ALTERNATIVE USES

- Historic Data Collection

NEEDS

DATA NEEDS/PROBLEMS

- HEC-1 Models
- High Speed Computer
- Communication Lines

ARIZONA DEPARTMENT OF WATER RESOURCES

Summary of Interviews with Dan Lawrence and Wayne Cooley on 31 August 1994 and 4 April 1995.

RESPONSIBILITIES

LEGISLATIVE MANDATE (ARS 45:1501-1506)

- **Establish a Statewide Flood Warning System**
  Following the floods of January 1993, the State of Arizona Legislature passed an act which appropriated flood relief funds. In addition, the act authorized the ADWR to establish a statewide flood warning system. The act defined flood warning system as a project(s) to detect floods, including ALERT systems, and develop flood preparedness plans.

  - **Coordinate with federal agencies**
    ADWR is authorized to cooperate and coordinate with federal and local entities in establishing a flood warning system for the state. The ADWR is currently cooperating with USGS, NWS and the COE in the acquisition and installation of hydromet data collection and dissemination systems.

  - **Assist local entities**
    ADWR may assist communities technically and financially in the design, installation, operation and maintenance of flood warning systems, including ALERT systems. ADWR has the authority to enter into intergovernmental agreements with local entities.

  - **Set statewide policy**
    Because of its statewide authority, ADWR is able to set statewide policy on the installation of flood warning hardware and software.

- **Flood Warning System (FWS) Fund Disbursements**
  When a local entity applies for funding assistance, ADWR is directed to make a full and careful investigation of the qualifications of the applicant and the proposed project. ADWR determines whether the proposed flood warning system would provide meaningful flood warning and is in the best interest of the state. Thereby, ADWR directly influences the selection of the areas of the state which need detection systems and determines what instrumentation would best serve those areas. Upon approval, ADWR provides financial assistance to the local entities through disbursements from the FWS Fund. The Director of Water Resources is responsible for administering the fund.

- **Provide Technical Assistance**
  ADWR provides technical assistance to local entities to develop and maintain flood warning systems. ADWR may assist local emergency managers develop training and maintenance programs so that the maximum utility of the systems is realized.

FLOOD WARNING

ADWR receives flood warning notification from the NWS via pager. ADWR does not make forecasts or issue warnings and does not want to assume that responsibility.

RESOURCES

FLOOD WARNING SYSTEM (FWS) FUND

A FWS Fund is established in the State Treasury for developing a statewide flood warning system, purchasing flood warning system equipment and providing assistance to local entities on a cost sharing basis for the planning, design, installation, operation and maintenance of flood warning systems. No grant may be more than 75% of the cost of equipment necessary to install the flood warning system.

The funding source for the FWS Fund consists of legislative appropriations, grants and contributions from other public agencies.

EQUIPMENT

The specification, procurement, installation, and maintenance of flood warning hardware is one of ADWR's primary functions with regard to the flood warning system.

- **Procurement**
  In accordance with the authorizing legislation, ADWR may coordinate and cooperate with the federal government or local entities in establishing a data collection system for flood warning purposes. ADWR is coordinating with several federal agencies on current projects directly related to flood warning. ADWR has provided funding for 38 gages in cooperation with USGS. The ADWR has procured 10 weather stations which will provide meteorologic data for flood warning purposes and potentially for atmospheric research. Additionally, ADWR is coordinating with the COE on flood warning projects in Mohave County and Willcox, Arizona; and on the COE Arizona Flood Control Study focusing on non-structural flood warning solutions on a statewide basis.

  ADWR also has entered into agreements with local entities to purchase ALERT systems for Yavapai County and Sedona, Arizona. Similarly, ADWR has procured equipment to establish flood warning systems in Gila County, Navajo County, and Pinal County. At the state level, ADWR is in a position to deal uniformly with equipment suppliers and can develop an ongoing relationship with them. This will insure that all equipment in the state is of a standard design and that it will interoperate with the rest of the system.

- **Installation**
  The installation of hydrologic instrumentation requires considerable expertise. Mechanically, a trained installer can insure that the equipment is properly set up and that it will be able to report to the other components of the system. Hydrologically, the proper siting of instruments requires considerable professional judgment. ADWR provides this service to local entities within the state.

  Under a cooperative agreement with ADEM, the ADWR is currently involved in the installation of instrumentation in Clifton, Arizona. This equipment is part of the flood warning component of a COE flood control project for Clifton. The equipment is installed in the field and in the process of being tested.

- **Training**
  ADWR provides the end users with training on the proper operation of their equipment. The training often takes place as the equipment is installed and addresses both hardware and software operation.

- **Maintenance**
  The local entities are responsible for the operation and maintenance of their component of the statewide flood warning system. It is unlikely that smaller organizations will be able to afford to hire permanent maintenance technicians for this specialized equipment. ADWR may provide the required maintenance service or contract with a private company with funds provided by the local agency. The authorizing legislation provides specific guidelines as to ADWR's role in overseeing equipment maintenance should the local entity fail to do so.

  A standard roster of maintenance items and service intervals necessary for a regular equipment maintenance program is currently being developed by a committee comprised of ADWR, SRP, USGS, NWS and FCDMC.

PERSONNEL

- **ADWR Flood Warning Staff**
  The enabling legislation authorizes the Director of Water Resources to employ a staff to provide technical assistance. The current Flood Warning Section staff consists of a lead supervisor, two installation/maintenance technicians, and a hydrologist/modeler.

- **Emergency Operations**
  ADWR flood warning staff have a supporting role during actual flooding emergencies. Their job is not to issue warnings; rather, it is to provide technical advice to emergency response agencies as to what those warnings mean with respect to the impacted watersheds. During a storm with flooding potential, ADWR sends staff to the NWS to aid in the determination of affected areas. Similarly, the ADWR provides technical support to the Arizona Division of Emergency Management (ADEM) during weather emergencies. ADWR may also provide advance notice to local response agencies when conditions warrant.

  In order for this emergency support resource to be of value, ADWR flood warning staff require training relative to flood warning system equipment and in the response characteristics of various basins within the state. For this reason, ADWR needs a fully operational node in the statewide flood warning communication system.

CAPABILITIES

DATA COLLECTION

ADWR currently operates a base station which collects data from almost all ALERT sensors statewide. Even during times of no flooding, an automatic monitoring capability contained within the ALERT system alarms operators of the need for maintenance, such as batteries replacement or semi-annual maintenance checks. Additionally, ADWR will be receiving NEXRAD special subscriber products by the end of 1995.

TECHNICAL AND FINANCIAL ASSISTANCE

ADWR is authorized to assist local entities by providing the technical expertise of its staff and by allocating grants from the FWS Fund to defray the cost to the local entity for the process required to establish a flood warning system. ADWR may assist in the planning and design of a flood warning system, and the purchase and installation of the necessary equipment. ADWR may provide assistance in the initial operation of the system, including hydrologic and hydraulic modeling and system calibration. ADWR solicits input from each local entity regarding modeling and engineering issues depending on their level of expertise.

FWS OPERATION AND MAINTENANCE

The local entity is responsible for the operation and maintenance component of a flood warning system; however, ADWR may provide training, technical assistance and ongoing oversight to the local entity.

- **Technical Training**
  ADWR currently conducts training in the operation of the hardware and software that it installs. Potentially, this training responsibility could evolve to include other aspects of flood warning. Emergency response organizations (fire departments, police, city managers, etc.) will require training in the use of their flood warning systems. This includes both how to use the equipment and what to do when various warnings and alarms are in effect.

- **Basin-Specific Flood Warning Plans**
  ADWR staff are familiar with the response characteristics of basins statewide. ADWR is positioned to be a major contributor to the development of emergency response plans specific to those basins. ADWR's modeling capability will facilitate the determination of appropriate warning times for a given basin and the mapping of evacuation routes. The system may be calibrated so that operators know how much time they have to implement plans during an actual event.

  Based on the response characteristics determined by modeling, it may be possible to develop graduated response plans. Thus, early stages of the plan might simply require that the base station be activated and continuously monitored. Later stages might require evacuation.

- **Coordinated Exercises**
  The statewide flood warning system will require the cooperation of a number of organizations to make it work. Such coordination will be dependable only if it is exercised periodically. The Arizona Division of Emergency Management (ADEM) may be primarily responsible for system exercise, however ADWR has the capacity to assist in the design and conduct of such exercise. ADWR is able to design the hydrologic scenarios for training exercise to insure that the equipment that it installs and maintains is operational. ADWR may also provide input as to where the flooding trouble spots are in Arizona so that their flood warning systems and response plans are properly tested during training exercise.

- **Equipment Maintenance**
  ADWR is authorized to complete equipment maintenance in cases where a local entity does not complete the required maintenance within 15 days of written notice from the Director of Water Resources. The Director may charge a local entity for the costs actually incurred in completing required maintenance or providing ongoing oversight of the operation and maintenance of a component of the flood warning system.

ALTERNATIVE USES

- **Historic Data Collection**
  The basin instrumentation can be used to collect hydrologic data for future use. Current plans are for the State Climatologist to archive the data once it has been checked for quality control.

  Historical hydrology can be used in risk management by evaluating the risk from flooding for emergency planning, operational policies, or for the siting of roads and structures, etc. Additionally, hydrologic data is used to determine probable flows in the design of bridges and flood control structures. In floodplain management, this data may be used to determine floodplain boundaries for National Flood Insurance Program purposes.

  ADWR is the state agency responsible for the safety of dams. The improved hydrologic data provided by the flood warning system will be valuable in discharging that responsibility.

NEEDS

DATA NEEDS/PROBLEMS

- **HEC-1 Models**
  HEC-1 models are needed for each watershed and subwatershed that the state is monitoring.

- **High Speed Computer**
  High speed computer and communication lines are needed to share ALERT and NEXRAD data with others.

SALT RIVER PROJECT

Interview Summary Outline

RESPONSIBILITIES	RESOURCES	CAPABILITIES	NEEDS
MISSION • Reclamation Heritage - Provide low-cost water to shareholders - Sell electricity to subsidize water • Changing Mission - Response to increasing urbanization - Physical constraints of the dams - New operating policy • Expanding Vision - Comprehensive water resources management - Expanding market focus **FLOOD WARNING** • Notification Procedure - Winter Storms - Summer thunder-storms	**DATA COLLECTION** • Basin Instrumentation - Precipitation gages - Stage gages - SNOTEL gages - Antecedent soil moisture • Meteorological Tools - Satellite data - Radar data - PRISMS - Lightning data • Reservoir Level Telemetry	**DATA ANALYSIS** • Monitoring Function - Hydromet data • Forecast Function - Local basin QPF - Long-range forecasts • GEOSHED Model	**DATA NEEDS/PROBLEMS** • Receives Adequate Data • Need for Standardizing Data Format • Communication

SALT RIVER PROJECT

Summary of Interview with Dallas Reigle, Yvonne Reinink, and Jon Skindlov on 30 August 1994.

RESPONSIBILITIES

MISSION

- **Reclamation Heritage**
  The traditional mission of SRP is founded in the Project's reclamation heritage. SRP functions to provide an adequate and reliable supply of low-cost water to its shareholders. Selling electricity is critical to accomplishing this task. The power generation function has traditionally served to subsidize water for irrigation.

- **Changing Mission**
  - **Response to increasing urbanization**
    As the characteristics of SRP's service area have changed, so has the focus of the Project's mission changed from meeting the needs of an agricultural community to serving an ever increasing urban area. This shift in mission focus is evident in the changing pattern of water use. Previously, there was low use in the fall, winter and spring with the peak demand occurring during the summer months. Now, there is a trend toward increasing water demand during the spring and fall.

  - **Physical constraints of the dams**
    The SRP reservoir system was originally designed for water supply purposes only. The physical constraints of the dams are such that there is no reservoir capacity dedicated to flood control and the dams are not operated for that purpose. The raising of Roosevelt Dam, currently underway, will provide space for flood control and safety of dams purposes in the future, not additional space for water supply storage. This will give SRP some needed flexibility in operating the reservoir system because Roosevelt Lake represents the majority of the available storage in the SRP system.

  - **New operating policy**
    During the past two years, the emphasis for reservoir operations within SRP has shifted from the traditional "fill and spill" policies common to western reservoirs toward a more comprehensive management. The project will use its watershed monitoring and forecast capabilities to manage the system with the goal of having the reservoirs as full as possible at the end of the spring runoff season. To accomplish this goal, SRP may release water between winter storms to help lower the peak flows that occur during those storms when the reservoirs are full.

    This shift in management emphasis requires more data based decisions and, therefore, the latest in meteorological and hydrologic forecasting tools. Toward that end, SRP Water Resource Operations has invested heavily in both hardware and software for data communication and analysis.

- **Expanding Vision**
  - **Comprehensive water resources management**
    The flooding of the late 1970's and early 1980's triggered an increase in watershed monitoring efforts to more effectively manage the water supply, not primarily for flood

warning purposes. The missional directives governing the daily operation of the reservoir system are oriented toward comprehensive water resources management and resource stewardship.

- **Expanding market focus**
  SRP seeks to be the premier provider of the electric and water services essential to support the Salt River valley. The changing business environment has created a greater number of options for traditionally captive customers in meeting their water and energy needs. Although SRP will stay within the water and power industries, the Project's response to the new business environment may include pursuing other lines of business or new markets.

FLOOD WARNING

The SRP flood warning capability has been developed to aid them in the operation of their reservoir, canal and power systems. This capability has resulted in a unique relationship with the National Weather Service as well as the ability to perform independent analysis of the weather.

- **Notification Procedure**
  - **Winter storms**
    During the winter, the major source of flooding is large general storms having durations from several days to weeks. In this case, the major concern is excessive flows in the Salt and Verde Rivers. Historically, the highest peak flows have come from the Verde River while the Salt River has provided the greater total volume of flood water. The addition of flood control space in Roosevelt Lake created by the raising of the dam will accentuate this difference.

    The major flood warning function of SRP in this case is to anticipate river flows and coordinate with the appropriate agencies to notify them of the flows that will occur below Granite Reef Dam. The notification procedure consists of a two step process. SRP conducts agency briefings to provide information regarding the potential for water releases into the river. These oral briefings are held only when conditions warrant. When the discharge in the river reaches a certain amount, a call-out list of agencies and municipalities is notified by a broadcast FAX or telephone call to alert them of anticipated releases. Those notified in this manner might include city governments, sand and gravel operators, county highway department, construction contractors in the river, Sheriff's Office, the Maricopa County Department of Emergency Management, Arizona Department of Public Safety (DPS), and the Arizona Department of Transportation (ADOT). This information is relayed to the general public through news releases via radio, television and newspapers.

- **Summer thunderstorms**
  During the summer, the major source of flooding is local thunderstorms. Here the major function of SRP is to perform internal warning so that the canals will not overtop and water will be conserved to the extent possible. The local storm warning function also serves to allow the power side of the company to position emergency crews for damage control.

RESOURCES

DATA COLLECTION

- **Basin Instrumentation**
  SRP has access to a wide variety of field instrumentation within the Salt and Verde River basins. SRP owns and maintains the minority of this instrumentation; the majority is owned by the USGS, and others.

  - **Precipitation gages**
    The precipitation gages report by a combination of satellite uplinks and radio repeaters. They routinely collect data at 15 minute intervals and transmit to the SRP computers every 4 hours. If an event occurs which exceeds a preset threshold, the gage will begin transmitting every 15 minutes on a separate emergency channel frequency until the event is complete.

  - **Stage gages**
    SRP maintains a network of stream gages in the Salt and Verde River basins. These gages report either by radio or by satellite link to Water Resources Options computers at SRP.

  - **SNOTEL gages**
    SRP has access to SNOTEL gages in the upper regions of the basin. The SCS and SRP collect snow survey data consisting of snow water equivalent, depth, elevation and areal extent.

  - **Antecedent Moisture**
    During the winter storm season, SRP will survey basin soil moisture every two weeks at five points within the Salt/Verde watershed. Data is kept as a time series. During the summer this is done less often. Although the soil dries out more quickly during the summer, thunderstorms do not have the same potential for severe reservoir flooding as is possible with winter storms.

- **Meteorological Tools**
  - **Satellite data**
    The new SGI Onyx computer will enable SRP to directly receive GOES satellite imagery and process that data at individual workstations. SRP receives one-half hour updates of mesoscale satellite imagery. While this capability allows SRP meteorologists to track long duration winter storms, its greatest value in terms of flood control may prove to be as a supplement to the new radar tools being developed. As such, real time satellite pictures could cover for gaps in radar coverage as well as give warning of storms developing out of range of fixed site radar.

  - **Radar data**
    SRP currently receives Level 2 Doppler weather surveillance radar data (Model WSR-88D) as part of a short-term research program with NSSL and EPRI. They can receive radar data at 5 minute intervals. SRP receives the satellite down-load and processes the data selecting spatial and temporal distribution to achieve the required resolution. A new software platform for this data is expected next year. SRP is currently working with the National Severe Storms Laboratory (NSSL) to develop new products and algorithms for use with the WSR-88D radar data.

- **Phoenix Real-Time Instrumentation for Surface Meteorological Studies (PRISMS)**
  The SRP PRISMS system is a network of 17 weather stations located throughout the Phoenix area. They collect temperature, humidity, wind speed and direction, pressure and precipitation. SRP applies a quality assurance program to the data to detect problems. These data are archived at 5 minute intervals by the State Climatologist at ASU.

- **Lightning data**
  Lightning data is provided by Geomet Services in Tucson. It allows real time display of lightning activity within Arizona and the Phoenix valley.

- **Reservoir Level Telemetry**
  SRP currently collects reservoir level and release data electronically. These data are not broadcast, nor are they directly available to outside agencies.

CAPABILITIES

DATA ANALYSIS

- **Monitoring Function**
  - **Hydromet data**
    The floods of the late 1970's and early 1980's indicated a need for increased instrumentation to monitor the SRP watershed more effectively to facilitate operation of the reservoirs. A large program ensued consisting of the automation of the existing gages in the state and the installation of additional gages, in come cases redundant. The USGS was responsible for the installation and maintenance of the gages. ADWR was largely responsible for the funding of the program under its flood warning authority. As a result, the density of the instrumentation network in Arizona equals or exceeds that found in most other states.

    The data generated by SRP is intended to support the project in fulfilling its mission and, therefore, is generally not made available to outside entities. The incoming streamflow to the reservoir system and the lake level data are relayed into separate systems at SRP which do not cross communicate and cannot be accessed by dial-in users outside SRP. The USGS data, NWS weather data, PRISMS data, and lightning data are also received into the SRP system.

- **Forecast Function**
  - **Local basin QPF**
    The National Weather Service (NWS) is the official forecast office for the State and, as such, prepares and disseminates weather forecasts, flood watches and flood warnings. SRP has the meteorological capability in-house to develop forecasts tailored specially to the SRP watershed. SRP prepares local basin quantitative precipitation forecasts (QPF) and other tailored meteorological products for operational use. This information is for internal use only is not disseminated to outside agencies. Agencies external to SRP must rely on the official basin QPF generated by the NWS with some input from the Colorado Basin River Forecast Center (CBRFC) and SRP.

- **Long-range forecast**
  Long-range forecasts of the seasonal outlook generated by SRP are shared with other agencies after they are released internally.

- **GEOSHED Model**
  The GEOSHED computer model is used to define the characteristics of a watershed. The model interfaces with the HEC-1 hydrologic model to compute runoff from a basin using incoming real-time rainfall data. A text product indicating the predicted runoff from a particular basin resulting from the amount of measured rainfall during a storm event would be useful information to make available to users of the statewide flood warning system.

NEEDS

DATA NEEDS/ PROBLEMS

SRP currently receives the data necessary to fulfill its mission during storm events. SRP does not perceive a need for more data; however, any additional, reliable data would be useful in fine tuning their analysis for decision making. An example of this is the desirability to gather additional antecedent soil moisture data to support more accuracy in hydrologic modeling of the basin.

SRP anticipates the need in a Statewide Network for a means of standardizing data format. The system will eventually receive data from diverse sources (i.e. ALERT, satellite, etc.), from equipment/sensors of different manufacture, and at varying intervals. The system concept design should consider these factors.

SRP expressed a need for better communication among agencies operating major dams in Arizona during flood events. Experience gained during the January 1993 floods indicated that communication via telephone and FAX between SRP and other agencies proved cumbersome and inefficient. To avoid repeating these problems, a two way information flow within the Statewide Network is needed. SRP needs easier access to data from COE and the USBR relating to operations at Painted Rock Dam and Coolidge Dam, respectively. Similarly, those and other agencies need dial-in access to SRP data to avoid FAX communication problems. A proposed temporary solution to this issue until a statewide flood warning system can be implemented is to use the Internet for information exchange. SRP noted that different levels and means of communications are required for different governmental or emergency response agencies, predicated on their data needs and levels of expertise.

PIMA COUNTY FLOOD CONTROL DISTRICT

Interview Summary Outline

RESPONSIBILITIES	RESOURCES	CAPABILITIES	NEEDS
MISSION • Protect Public Safety • Floodplain Management • Flood Control Engineering • Flood Detection • Emergency Preparedness **FLOOD WARNING** • Consult with NWS • No Public Warning Responsibility • Field Requests for Information **FLOOD RESPONSE** • Field Verification • Monitor Instrumentation	**DATA COLLECTION** • ALERT System • Kavouras Radar • Observer Network **DATA GENERATED** • Operational Data • Archive Data **FUNDING SOURCES** • PCFCD Levy • State Assistance for Flood Detection System • Federal Grant Programs	**DATA ANALYSIS** • Forecast Models • Model Calibration **FLOODPLAIN MANAGEMENT** • Identify Flood Limits • Critical Breakout Points • Establish Trigger Points **PUBLIC AWARENESS** • Media • Pamphlets • Educational Consultant **ALTERNATIVE USES** • Research • Legal Needs	**DATA NEEDS/PROBLEMS** • Redundant Systems • More Gages • Funding **DESIRED PRODUCTS** • Uniform Radar Product • Local Warnings/QPF • Predictive Hydrographs

PIMA COUNTY FLOOD CONTROL DISTRICT

Summary of Interview with Tom Helfridch on 21 September 1994

RESPONSIBILITIES

MISSION

The mission of the Pima County Flood Control District (PCFCD) is to comply with federal and state laws governing floodplain management, public safety, and the environment. PCFCD protects public safety and welfare through effective floodplain management and flood control engineering, as well as early flood detection coupled with emergency preparedness.

FLOOD WARNING

During a storm event, PCFCD's role is not to disseminate flood warnings, rather it is to provide support to those that do. PCFCD collects, processes, and disseminates data to the NWS Tucson, Pima County Department of Emergency Management (PCDEM), Pima County Department of Transportation (PCDOT) personnel, and the Pima County Sheriff's Office. Since PCFCD has staff hydrologists familiar with data collection, interpretation and hydrologic modeling of the response characteristics of the basins, they often provide support to the NWS in issuing flood watches and warnings.

PCFCD relies on the NWS or PCDEM to disseminate warnings to the public. The reasons for this are that NWS and PCDEM have other sources of information and they have the necessary communication linkages to effectively issue public warnings. This also ensures that the public receives one message and need not discern between conflicting information. While PCFCD does not directly contact the public during an emergency, the District does field calls for information from private citizens, the media, school districts or other county agencies to which they provide a response.

FLOOD RESPONSE

PCFCD maintains two-way communication with the NWS and PCDEM during an event. They provide field verification through field inspections and damage assessment surveys. PCFCD monitors their instrumentation system during an event. In addition to their own ALERT gage system, PCFCD has Kavouras radar service. During an event, they videotape the radar display.

RESOURCES

DATA COLLECTION

- **ALERT System**
  PCFCD maintains a network of ALERT gages and weather stations in the basins that they monitor. PCFCD collects real-time data from 62 rain gages, 30 stream gages and 2 weather stations located at 62 sites in Pima County and southernmost Pinal County. There are two stand alone base stations located at PCFCD and NWS Tucson. Agencies with dial-in access to the Pima County ALERT System include:

- PC Department of Emergency Management
- PC Department of Environmental Quality
- PC Operations Department
- Metro Fire Department
- NWS Phoenix
- Saguaro National Monument
- Tucson Water
- USGS

There are 3 modems available for dial-in. PCDEM has all 3 numbers, the others only have one.

- **Kavouras Radar**
  PCFCD uses Kavouras radar service to monitor storm development and movement. the radar display is beneficial in assessing the areal extent of storms and the storm track. ALERT data compliments Kavouras radar by providing ground truth to the radar display. PCFCD videotapes the radar display during an event.

- **Observer Network**
  There is a network of volunteer observers who monitor rain gages and stage in rivers and washes. The observers are requested to report to the PCFCD if they receive one inch of rain during an event. The information generated by the observer network provides field verification of the telemetered ALERT data.

DATA GENERATED

- **Operational DATA**
  Operational data is used as it is received in real-time to carry out emergency response functions. It is not checked other than through the experience of the operator. This data is recorded for later quality checking and use in studies. Operational data is available by dial-in modem to other county and outside agencies. There may be a need for permanent storage of operational data to preserve a record of what information was available to emergency managers as they made their decisions during an event.

- **Archive Data**
  Data that has been quality checked is archived for use in various studies and reports. PCFCD has an active program of quality control for their data.

FUNDING SOURCES

- **PCFCD**
  The District itself is funded through tax levy, bonds, grants and federal funding.

- **Flood Detection System**
  The ADWR provided financial support for the initial basin instrumentation along with Pima County and the NWS. More recently, USBR has provided additional funding through a groundwater recharge pilot program on Rillito Creek.

CAPABILITIES

DATA ANALYSIS

PCFCD performs analyses of data to support decision making during flood events. PCFCD interprets ALERT data, evaluates Kavouras radar, NWS statements, monitors CNN news, rain gage volume and field reports. They consider previous weather conditions and antecedent soil moisture. PCFCD does some rudimentary plot and forecast models to determine appropriate emergency response. They also calibrate hydrologic models to historic ALERT data to improve their forecast predictions in the future.

FLOODPLAIN MANAGEMENT

- **Identify Flood Limits**
  PCFCD delineates the floodplain boundary for floods of various return frequencies. The 100-year floodplain is used for insurance and regulatory purposes. Winter storm data is used for these studies. There is less data for summer storms and that data is not considered to be of sufficiently good quality to support risk analysis.

- **Critical Breakout Points**
  One purpose of the various floodplain studies is to identify hydraulically significant points where water is likely to breakout of its course and cause further damage.

- **Establish Trigger Points**
  Hydrologic modeling and hydraulic analysis of past flood events help to determine trigger points in washes where states should be monitored during an event. These analyses are most useful in conjunction with an established emergency response plan. The goal is to give emergency management agencies as much lead time as possible without generating false alarms.

PUBLIC AWARENESS

PCFCD has an aggressive public awareness program to educate the public about the dangers of flooding in the desert. They sponsor public service announcements on television and radio. They offer free pamphlets and other floodplain management information to the public. They have hired a consultant to instruct school children in the dangers of desert floods and offer coloring and activity books.

ALTERNATIVE USES

Alternative uses for data from the PCFCD flood detection system include environmental monitoring, groundwater recharge studies, range management, forest fire condition warning, and legal research.

NEEDS

DATA NEEDS/PROBLEMS

- **Redundant Systems**
  Recent experience during the 1993 floods indicated that for the most part, the PCFCD flood detection system functioned successfully. Common problems were failures in communication linkages resulting in the loss of critical data necessary to support decision making. Failures in electrical and computer systems, and the loss of telemetered data communication emphasized the need for redundancy on the entire system.

- **More Gages**
  Additional gages in the field would supply a more adequate database from which to plan emergency response. More gages in remote areas must be funded, maintained and calibrated. It is desirable for stream gages to have rating tables so that the data report discharge rather than stage. Streamgages have been especially problematic; many failures occurred in 1993 for various reasons. The gages were either programmed incorrectly, poorly maintained, had float or pressure transducer failures, or were vandalized.

- **Funding**
  Funding is need to properly maintain the basin instrumentation, especially streamgages. Funding for an additional staff hydrologist is also needed.

DESIRED PRODUCTS

- **Uniform Radar Product**
  PCFCD and Tucson are currently on the fringe of radar coverage from the Phoenix Doppler radar. A new WSR-88D radar will be commissioned in 1996 at the NWS Tucson NWSFO as part of the NWS modernization. New NEXRAD products will improve the coverage in Pima County. With this expanded coverage, there is a need to provide some standard products that will serve flood warning purposes. These radar products must be affordable for local agencies. PCFCD would like the state to use its resources to fund the standard products on the Statewide Network to be used by many counties.

- **Local Warnings/QPF**
  NWS watches and warnings are currently too general. PCFCD would like more localized advisories tailored to specific basins. Local weather reports and QPF's would be beneficial. An expanded NWS presence in the Tucson NWSFO is expected to improve the situation.

- **Predictive Hydrographs**
  PCFCD perceives a need for easy-to-use, reliable hydrologic models for each basin to test different scenarios and forecast basin response.

US GEOLOGICAL SURVEY

Interview Summary Outline

RESPONSIBILITIES	RESOURCES	CAPABILITIES	NEEDS
MISSION • Collect Water Resources Data - Instrumentation - Maintenance - Data Collection - Archiving • Problem Oriented Projects	**COMMUNICATIONS** • Satellite Ground Stations Receive Gage Data • File Transfer Protocol to USGS Tucson • Access to Gage Data by Other Agencies via Modem or Telnet	**FLOOD EMERGENCY OPERATIONS** • Ensure Gages Function Properly • Keep Communication and Data System Up • Handle Information Requests • Verify Ratings at Streamgage Sites **ALTERNATIVE USES** • NPDES • NAWQA	**DATA NEEDS/PROBLEMS** • System Redundancy • Archiving Data **DESIRED PRODUCTS** • GEOSHED Model • Radar Products

US GEOLOGICAL SURVEY

Summary of Interview with Chris Smith on 21 September 1994

RESPONSIBILITIES

MISSION

The US Geological Survey (USGS) has the principal responsibility within the Federal Government to provide the hydrologic information and understanding needed by others to achieve the best use and management of the Nation's water resources. To accomplish this mission, the Water Resources Division, in cooperation with State, local, and other Federal agencies:

- Systematically collects and analyzes data to evaluate the quantity, quality, and use of the Nation's water resources and provides results of these investigations to the public.

- Conducts water resources appraisals describing the occurrence, availability, and physical, chemical, and biological characteristics of surface and groundwater.

- Conducts basic and problem-oriented hydrologic and related research that aids in alleviating water resources problems and provides an understanding of hydrologic systems sufficient to predict their response to natural or human-caused stress.

- Coordinates the activities of Federal agencies in the acquisition of water resources data for streams, lakes, reservoirs, estuaries, and groundwater.

- Provides scientific and technical assistance to hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Energy Regulatory Commission, and to international agencies on behalf of the Department of State.

- Administers the State Water Resources Research Institutes Program and the National Water Resources Research Grants Program.

RESOURCES

COMMUNICATIONS

Beyond the USGS's extensive instrumentation for the collection of water resources data, the communications system for the transmission of that data is another important resource.

Most USGS gage data is transmitted via GOES satellite. The Arizona District office of the USGS receives its data from a ground station in California and has backup data coming from ground stations in Arkansas and Virginia. The data is sent via phone line file transfer protocol from one of the three ground stations. The USGS provides modems for other agencies to dial in during an event and retrieve gage data. Also, telnet can be used to link to the USGS computer system through Internet. USGS Field Offices in Tucson, Tempe, Flagstaff, and Yuma have dedicated lines to the District Office.

Due to the communication path and the reporting frequency of the gages, the data in the USGS Tucson computer will be anywhere from 5 minutes to 4 hours old before it is available to users. During normal operation, transmissions occur every four hours. During flood conditions when thresholds are exceeded, transmissions occur every 15 minutes.

CAPABILITIES

FLOOD EMERGENCY OPERATIONS

During a flood event, the USGS ensures that data is being collected and transmitted by the instrumentation in the field and the communication system is up and functioning correctly. They make sure that other agencies are provided access to the data they need from the database via modem or telnet.

The USGS staff handles telephone calls requesting more information by outside entities. The USGS sends field personnel into the field during flow events to verify the rating curves for the channels where they collect data.

ALTERNATIVE USES

Alternative uses for measured runoff data and water quality data from collected samples would be related to the NPDES and/or NAWQA water quality program compliance.

NEEDS

DATA NEEDS/PROBLEMS

- **System Redundancy**
  The USGS perceives a need for back-up computer equipment to provide redundancy in the USGS Tucson system. The USGS makes every effort to keep the system up during flood events, but there is no guarantee of uninterrupted service.

- **Archiving Data**
  The USGS identified potential problems in the archiving of data from diverse sources into a common format for the Statewide Network. This issue will need to be further addressed.

DESIRED PRODUCTS

The USGS is interested in utilizing the GEOSHED model for interfacing real-time hydrological data into HEC-1 models for reconstructing missing data.

Access to a suite of NEXRAD products would be useful to the USGS. Plans for the USGS and the NWS Tucson NWSFO to collocate in 1996 may address this need.

US BUREAU OF RECLAMATION

Interview Summary Outline

RESPONSIBILITIES	RESOURCES	CAPABILITIES	NEEDS
MISSION • Traditional Reclamation Heritage • Changing Mission - Resource management - Infrastructure maintenance **FLOOD CONTROL** • Safety of Dams • Operation of Small Projects **FLOOD WARNING** • Early Warning System (EWS)	**DATA COLLECTION** • Dam Instrumentation • Access to USGS and NWS Data Systems	**DATA ANALYSIS** • Hydrologic Analysis **CONSTRUCTION** • Infrastructure Upgrade or Repair	**DATA NEEDS**

US BUREAU OF RECLAMATION

Summary of Interview with Mary Brechler on 1 September 1994

RESPONSIBILITIES

MISSION

The traditional mission of the USBR has been reclamation of the arid lands of the western United States to support agriculture and municipal growth. Toward that end, they have been the agency responsible for the construction of many of the dams impounding reservoirs in Arizona. The mission of the USBR is in flux. In the past several years, that mission has been changing to resource management and the maintenance of the infrastructure the USBR has created.

FLOOD CONTROL

The USBR flood control interest mirrors the changing mission. The pattern has been for the USBR to assume temporary responsibility for a facility during its repair or upgrade and then return operation to a client organization once the work is complete. They expect this pattern to continue in the future.

- **Safety of Dams**
  Safety of dams is a major USBR concern both because they have constructed so many dams within Arizona and because they may assume control of various projects for repair and upgrade. For example, the Bureau of Indian Affairs (BIA) has requested assistance from USBR relative to safety of dams modifications on Coolidge Dam. The purpose of the rehabilitation construction is to correct hydrological, structural, and stability safety deficiencies identified at Coolidge Dam. The USBR will relinquish responsibility for the dam to the BIA upon completion of the project. Similarly, modifications to Bartlett and Horseshoe Dams will resolve dam safety problems on the Verde River.

- **Operation of Small Projects**
  USBR may assume an operating role during the construction or maintenance of smaller projects on federal lands. In that case, they might acquire a local flood warning responsibility.

FLOOD WARNING

The USBR is not oriented to perform flood warning functions. The only flood warning performed by USBR of note is an Early Warning System (EWS), which became operational in 1991, installed to alert downstream communities of impending failure of Coolidge Dam. The EWS monitors the movement of the dam, seepage around the abutments, and downstream flows. Data from the EWS is transmitted to the Coolidge Control Center. If a problem arises, an audible alarm will go off at the dam and a warning signal will be sent to the Control Center which, in turn, contacts the Gila and Pinal County Sheriff's Offices in case of evacuation emergencies for the towns of Hayden, Kearney, and Winkelman, Arizona.

RESOURCES

DATA COLLECTION

- **Dam Instrumentation**
  The USBR has placed various instrumentation within the dams it operates for the purpose of monitoring pressure, material deformations, magnetic forces and shear within the dams. These instruments are designed to measure movement of the dam as well as water seepage through the structure, where applicable.

- **Access to USGS and NWS Data Systems**
  The Water Resources section of the USBR will log on to USGS data system to access telemetered raw data for the purpose of monitoring precipitation and streamflow. The data is used to predict inflows to the dams. This effort is not geared toward flood warning, rather it is primarily for safety of dams purposes. The USBR does not maintain streamgages. They will contract with the USGS for data gathering, if needed.

  The USBR also receives standard NWS weather products.

CAPABILITIES

DATA ANALYSIS

- **Hydrologic Analysis**
  The USBR has the in-house capability to analyze raw hydrologic data to monitor lake level fluctuation and streamflow into the dams. They utilize USGS data, NWS weather products, satellite images, and information from the SRP Project Reservoir Operation Plan (PROP) Committee to determine implications to their operations.

CONSTRUCTION

The USBR is currently or has recently been the primary contracting agency for the modifications and repairs to several dam structures in Arizona. These include dam safety upgrades to Bartlett and Horseshoe Dams on the Verde River, major renovations to Roosevelt Dam on the Salt River, and the rehabilitation of Coolidge Dam on the Gila River. Additionally, the Bureau has constructed New Waddell Dam on the Agua Fria River.

NEEDS

DATA NEEDS

Depending on the nature of the weather event and on the projects for which they are then responsible, USBR can either be a major player or an interested party. Their role is expected to change with both time and the nature of the various events. In all cases, they represent the federal presence and need to have access to the information flowing in the system so that they may be informed participants in major operational decisions. Because they expect to become responsible for a variety of facilities, they need a flexible capability.

NATIONAL WEATHER SERVICE

Interview Summary Outline

RESPONSIBILITIES	RESOURCES	CAPABILITIES	NEEDS
MISSION • Reduce Loss of Life and Property from Weather Related Events • Congressional Authorization to Issue Hydrometeorological Forecasts and Warnings **FLOOD WARNING** • NWS Procedures • NWS Flood Products - Watches - Warnings - Advisories - Statements - Forecasts • Dissemination of Products - NOAA Weather Wire - NOAA Weather Radio - NAWAS - AWINS - Personal Notifications	**DATA AND COMMUNICATIONS SYSTEMS** • Data Collection - LARC - GOES - ALERT - SNOTEL - Reservoir gages - Observers • Data Systems - HYDROMET - AFOS - NEXRAD - PRISMS - Goes WX Satellite **PERSONNEL** • NWS Modernization **FUNDING SOURCE**	**DATA ANALYSIS** • Hydrometeorological Expertise • Forecast Capability - CBRFC - NSSFC **ALTERNATIVE USES**	**DATA NEEDS** **DATA PROBLEMS** **COMMUNICATION** **DESIRED PRODUCTS**

NATIONAL WEATHER SERVICE

Summary of Interview with Tony Haffer, Dave Carpenter, Mike Franjevic, and Tom Zickus on 20 October 1994

RESPONSIBILITIES

MISSION

The National Weather Service (NWS) has been authorized by Congress to reduce the loss of life and property from weather related events through the timely issuance of meteorological and hydrological forecasts and warnings.

To accomplish its mission, the NWS gathers data from a variety of sources and uses that information to determine the potential hazard for any given area from events such as tornados, severe thunderstorms, winter storms, and floods. A partial list of information sources includes surface observations, balloon observations, severe weather spotters, law enforcement agencies, remote automatic sensors, radar and satellites.

The NWS produces and issues various hydrometeorolgical forecasts and warnings. These include routine forecasts, special or severe weather forecasts/warnings, and stream or river forecasts. Additionally, NWS receives vast amounts of outside agency hydrometeorolgical data and makes that data, as well as NWS data, available to users.

FLOOD WARNING

Generally, flood/flash flood watches are issued by the forecast office in Phoenix and focus on larger areas of Arizona. Flash flood warnings are issued by Phoenix and the local NWS offices (Flagstaff, Winslow, Tucson and Yuma) and are primarily county based. Though offices mention specific flash flood-prone areas in the warnings, the warnings are still oriented by counties or portions of counties. Flood warnings are issued by NEXRAD Weather Service Forecast Office (NWSFO) Phoenix for the state of Arizona. The flood warnings are issued by river basins for specific points or areas along the major streams and rivers and are based upon flood forecasts provided by the Colorado Basin River Forecast Center (CBRFC) in Salt Lake City.

- **NWS Procedures**
  The issuing office must determine whether there will be flooding and if the resulting flooding will pose a potential threat to life or property, or whether the effects of the flooding will be mainly an inconvenience. The potential for threats to life and property are covered by watch and warning products. Inconvenience flooding such as low water crossings is covered by advisories. No flooding may be covered by a statement or forecast.

  Determination of the use of the term "flash" is made by the forecaster responsible for the preparation of the products. If the intent of the product is to call attention to events that require rapid user response, then "flash flood" is the appropriate term. If the flooding follows the causative event by a longer period of time, then flood without the term "flash" is used. This is generally used for downstream points or larger rivers.

- **NWS Flood Products**
  - **Flood/Flash Flood Watch**
    Issued to inform the public that current and developing hydrometeorological conditions are such that there is a threat of flooding, but the occurrence of flooding is neither certain nor imminent.

  - **Flood/Flash Flood Warning**
    Issued to inform the public that flooding is imminent or in progress.

  - **Tornado/Severe Thunderstorm and Flash Flood Warning**
    A product which can be used to warn the public when flash flooding is expected to accompany a tornado or severe thunderstorm.

  - **Urban and Small Stream Flood Advisory**
    Issued to address non-life-threatening flooding of small streams, streets and low-lying areas. However, if the flooding becomes life-threatening, the flood/flash flood watch, warning and statement process would begin.

  - **Flood/Flash Flood Statement**
    Issued to disseminate follow-up information regarding a flood/flash flood event.

  - **River/Urban and Small Stream Statement**
    Issued to inform or follow up other statements or forecasts when <u>no</u> flooding is expected.

  - **River Forecasts**
    Issued to inform the public about flows along mainstreams which are <u>not</u> expected to cause flooding.

- **Dissemination of Products**
  - **NOAA Weather Wire**
    When the NWS issues a watch/warning/statement, the statement is disseminated to the public and local governments through various methods. The most important method is the NOAA Weather Wire. The Weather Wire uses satellite communications to provide extremely fast distribution of hard copies of the weather products to subscribers.

  - **NOAA Weather Radio**
    The second method is the NOAA Weather Radio (NWR). Nearly every NWS office operates a NWR transmitter broadcasting weather information 24 hours a day. During severe weather, a tone alert can be activated to use radios equipped with the alert feature to sound an audible alarm. The NWR is the only direct link the NWS has with the public.

  - **National Warning System (NAWAS)**
    All watches/warnings/statements are also read over the NAWAS circuits as soon as the products are sent from the NWS office. The System links national, regional, state and local warning centers with voice-only telephone circuits. The agencies in the State of Arizona that have NAWAS drops are all NWS offices, sheriffs offices, Department of Public Safety and county Departments of Emergency Services. The state Division of Civil Defense and Emergency Management also is on the circuit.

- **Arizona Weather Information System (AWINS)**
  The basis of the NWS flood warning network in Arizona is AWINS. AWINS provides a direct data communications link from the NWS to the emergency management community. Users have dial-in access to the NWS HYDROMET computer and text and graphical AFOS products via AWINS. At the present time, the state Division of Emergency Management (ADEM), Maricopa County and Yuma County Emergency Services have the necessary hardware and training to utilize AWINS. Plans include linking all 15 county emergency services offices to the AWINS network. NWS, in cooperation with ADEM, will provide the expertise and training to maximize AWINS utility by the counties.

- **Personal Notifications**
  NWS personnel make a few personal notifications relative to warnings or watches. Resources, manpower and time preclude maintaining extensive lists or expanding current ones. This is the least desirable option for dissemination and is used only in extreme cases.

RESOURCES

DATA AND COMMUNICATIONS SYSTEMS

- **Data Collection**
  NWS collects data from various basin instrumentation. Most hydrologic field equipment is owned and operated by other agencies.

  - **Limited Automated Remote Collection (LARC)**
    This data collection system allows users dial-in access to digital data from precipitation gages in the field. LARC precipitation gages are owned and operated by the NWS.

  - **Geostationary Environmental Orbiting Satellite (GOES)**
    This hydrologic data collection system functions to provide mesoscale satellite imagery. In addition, GOES provides the communication capability to report precipitation and stream gage digital data.

  - **Automated Local Evaluation in Real Time (ALERT)**
    The ALERT system consists of event-reporting precipitation and stream gages with automated data collection and processing both locally and at the NWS. These systems are owned and operated by other agencies. This real-time data is shared with the NWS for utilization in the preparation of forecasts and warnings.

  - **SNOTEL**
    The NWS has access to SNOTEL precipitation and snow gage data in the higher elevations of the state. The SCS and SRP collect snow survey data consisting of snow water equivalent, depth, elevation and areal extent.

  - **Reservoir gages**
    NWS obtains reservoir level and release data from various agencies operating dams in Arizona.

- **Data Systems**
  - **HYDROMET**
    The HYDROMET system contains the software package used by NWS to collect ALERT data from remote sources. AWINS users can access ALERT data, AFOS products and other hydrometeorological data on the HYDROMET computer system.

  - **Automated Field Operations System (AFOS)**
    AFOS is a wide area network connecting NWS offices locally, regionally and nationally. AFOS products include NWS forecasts, watches, and warnings in text and graphical formats.

  - **Next Generation Weather Radar (NEXRAD)**
    The new Doppler weather surveillance radar (Model WSR-88D) provides the technology to calculate both the speed and direction of motion of severe storms. WSR-88D data interpretation can increase advance warning, and the specificity of such warnings, for severe weather events. NEXRAD radar data provide high resolution, image products used as a basis for hydromet forecasts and warnings issued by NWS.

  - **Phoenix Real-Time Instrumentation for Surface Meteorological Studies (PRISMS)**
    The SRP Prisms system is a network of 17 weather stations located throughout the Phoenix area. They collect temperature, humidity, wind speed and direction, pressure and precipitation. SRP applies a quality assurance program to the data to detect problems. These data are reported to NWS and archived at 5 minute intervals by the State Climatologist at ASU.

PERSONNEL

The NWS currently has five offices in Arizona. The Forecast Office is located in Phoenix with local Service Offices in Tucson, Yuma, Flagstaff and Winslow. In general, weather watches and flood warnings are issued by the forecast office in Phoenix and all other warnings are issued by the office with responsibility for the affected county.

The NWS presence in Arizona will be changing significantly in 1996. Eventually, NWSFO's will be located at Phoenix, Tucson and Flagstaff concurrent with the installation of new Doppler radars at those sites as part of the nationwide NWS modernization program. NWS offices at Winslow and Yuma will be closed.

The weather forecast responsibilities for counties in Arizona will be assigned as follows:

- Phoenix NWSFO - Yuma, La Paz, Maricopa, Gila, Pinal Counties; Imperial, Riverside Counties in California
- Tucson NWSFO - Pima, Santa Cruz, Cochise, Graham, Greenlee Counties
- Flagstaff NWSFO - Coconino, Navajo, Apache, Yavapai Counties
- Las Vegas NWSFO - Mohave County

FUNDING SOURCE

The NWS funds much of the data and communications systems it uses. Supplemental funding is also provided by ADEM and ADWR.

CAPABILITIES

DATA ANALYSIS

- **Hydrometeorological Expertise**
  The NWS collects a large stream of data from a variety of sources. Internally, the data are the basis of the hydrological and meteorological forecasts and warnings issued by the NWS. From an external perspective, NWS forecasts are used by water managers and emergency response agencies to support decision making during flood events.

- **Forecast Capability**
  - **Colorado Basin River Forecast Center (CBRFC)**
    The CBRFC in Salt Lake City, Utah has the capability to forecast river flows from observed precipitation and quantitative precipitation forecasts developed by the NWS Phoenix NWSFO.
  - **National Severe Storms Forecast Center (NSSFC)**
    The NSSFC in Kansas City, Missouri prepares tornado and severe thunderstorm watch statements of interest to both the public and aviation sectors.

    When the forecast office in Phoenix receives a watch from NSSFC, a redefining statement is issued and all forecasts for the watch area are updated to headline the watch. If warranted, a tornado/severe thunderstorm warning is issued by the Arizona NWS office with warning responsibility for the affected area.

ALTERNATIVE USES

NWS perceives a large potential for alternative uses for the Statewide Network to maximize the utility during times of no flood emergency. Their list of alternative uses includes: routine weather and hydrologic products and on-line reference data; HAZMAT activity requiring special weather or stream flow forecasts; means of updating climatology; water management operations for drought, recreation, water supply, etc.; provide database and feedback for calibration of methods and procedures for hydrometeorological products; potential information for disasters such as dambreak.

NEEDS

DATA NEEDS

The NWS currently receives adequate data for preparing forecasts and issuing warnings. The imminent installation of additional Doppler radar sites in Arizona will make available even more data for NWS use.

The NWS identified the following other data needs: fifteen minute to hourly GOES satellite river and rainfall information with local downlink and "true" real-time access; automated spotter reporting network; automated reservoir status and operations information; Mean Areal Precipitation maps and estimates.

DATA PROBLEMS

Experience gained from recent flooding events has highlighted data problems and communication deficiencies. From an operations standpoint, there is a lack of quality control of data. Data and NWS product verification is lacking, especially in the more remote areas. Information pertaining to periodic gage outages during storms is of critical importance. NWS perceives a need for real-time notification of and accessibility to stream flow rating changes and rating shift adjustments during flood events and other wise improve data collection sites.

COMMUNICATION

The NWS identified deficiencies in communication during storm events as a primary concern. Recent experience during the floods of 1993 has shown that agency cooperation in data and information sharing and dissemination is improving. Active participation by outside agencies during NWS weather briefings, NWS participation in SRP PROP meetings, a computer link to the ADEM EOC, and the availability of NWS information through HYDROMET are all indications of a cooperative environment among agencies.

Areas where communications have been problematic is in communicating with local emergency response agencies. The AWINS network functions well to disseminate information out to the county emergency services agencies which are users of the network. However, a lack of expertise, training, and continuity of personnel at the local level causes the NWS to provide more information and support than originally intended.

Communications bottleneck problems result. Communicating of information via FAX is cumbersome and slows decision making. NWS receives little emergency management information such as road closures, evacuations, levee failures and deaths. With limited feedback from water managers and emergency management personnel during or immediately after events, the NWS gleans most information from the news media.

The NWS sees a major goal of the Statewide Network is to close the communications gap by providing a single, statewide data and information outlet. All data should be retrievable using a single source whether a single computer or a network server with dedicated access to all participating data source computers. Information should be accessible on a real-time basis, in a user friendly mode, quality controlled, and in a standard format. It should include vendor provided satellite and radar products. All data and products should be available to all users.

DESIRED PRODUCTS

The products that NWS would find useful on the Statewide Network should all be real-time accessible. These include reservoir operation products (status reports, current operations, future operations); event-damage logs; Mean Areal Precipitation maps and estimates; summaries of roadway outages or projected outages; outside agency river and rainfall reports.

US ARMY CORPS OF ENGINEERS

Interview Summary Outline

RESPONSIBILITIES	RESOURCES	CAPABILITIES	NEEDS
MISSION • Reservoir Regulation - Operate Painted Rock Dam • Emergency Response - Declared Flood Disasters - Emergency Flood Fighting	**DATA AND COMMUNICATIONS SYSTEMS** • COE Arizona Flood Control Study - Focus on Non-structural Alternatives - Proposed "Backbone" FWS - Identify Training Needs - Require Emergency Preparedness Plan - Evaluate Economic Benefits - Provide Funding for Hardware - O&M Responsibility of Local Sponsor	**STATEWIDE NETWORK SUPPORT** • Monitor System Performance • Training Support • Annual Exercises Participation	**COMMUNICATION** **DATA NEEDS/PROBLEMS** • Daily Reservoir Operations • Streamflow Data • Redundant System **DESIRED PRODUCTS** • Dam Release Projections • Basin-Specific QPF • Predictive Hydrographs

US ARMY CORPS OF ENGINEERS

Summary of Interview with Sam Arrowood on 21 October 1994

RESPONSIBILITIES

MISSION

The Corps of Engineers (COE) performs two main functions during a flood event. The Reservoir Regulation Section in Los Angeles operates Painted Rock Dam on the Gila River. Secondly, the Emergency Management Branch in Los Angeles coordinates an emergency response capability statewide.

- **Reservoir Regulation**
  Painted Rock Dam was designed to provide flood control only; no provision was made for water storage. Painted Rock Dam is located downstream of all the other dams on the Salt/Verde and Upper Gila River systems. The COE has significant lead time before floodwaters reach their dam to formulate operating plans. The Los Angeles COE office maintains contact with SRP and USBR to keep informed about those agencies' planned releases from their dams upstream of Painted Rock. The COE also can access NWS data via modem to obtain weather information. Based upon the projected inflows, lead time and weather forecasts, the COE Reservoir Regulation Section in Los Angeles develops a dam operations plan specific to that flood situation, and based upon an existing standard operations plan.

- **Emergency Response**
  The second function performed by the COE during flood events is emergency response. Their focus is on major events; the COE doesn't become involved until after a state or presidential declaration has been made.

  Following a declaration, the state can request assistance from the COE for emergency flood fighting during the event when the situation is beyond the resources of the state. Typical flood fight activities performed by the COE or their preselected contractors include sand bag placement, remedial repair of levee breaks, or raising levee height. In the case of a presidential declaration, the COE may become involved as part of the federal response plan coordinated by FEMA.

RESOURCES

DATA AND COMMUNICATION SYSTEMS

- **COE Arizona Flood Control Study (AFCS)**
  As a result of widespread flooding in Arizona in January 1993, the Congress authorized a study by the COE to identify corrective measures which must be taken to prevent flooding of similar magnitude in the future. The Arizona Flood Control Study Final Report is currently being reviewed internally by the COE and is not available for distribution until such review is completed.

  The AFCS focuses on the evaluation of nonstructural flood warning alternatives. The COE study proposes the installation of data collection hardware to provide flood

threat detection capability coupled with a communication capability within the system for flood warning dissemination. The proposed "backbone" flood warning system is intended to serve as a centralized, comprehensive source of flood warning information for federal, state, and county agencies and local emergency response entities.

The AFCS plan provides for the installation of approximately 120 ALERT precipitation and streamflow gages and 5 regional base stations linked to a central computer system. The COE plan calls for a redundant data and communications system. The central base station will also receive data from other existing gages (USGS, NWS, SCS, SRP, COE), lake levels, snow, lightning, and other ALERT systems. The flood warning capability is planned into the system by providing preset alarm thresholds that alert end users at the local level that emergency response is required.

The COE stresses the need to ensure the end users are provided timely, accurate information in an easily understood format so that the proper emergency response is enacted. The COE will require that adequate training is provided to users and periodic coordinated exercises are held. Essential to continued COE support of the AFCS proposed system is the development of Emergency Preparedness Plans by local entities.

The AFCS system is designed to accommodate later expansion and allows for additional gages, basins, and agencies to participate as the need arises. The AFCS has the local support of ADWR. The COE funding support is limited to hardware to provide a basic FWS for the state as dictated by the economic benefits. The proposed budget is $1.4M for design and installation of the basic system. ADWR, as the local sponsor, is responsible for the operation and maintenance of the system.

CAPABILITIES

STATEWIDE NETWORK SUPPORT

Upon implementation of a statewide FWS, the COE would perform a monitoring function. The COE would follow-up with the local sponsor, ADWR, in assessing system performance. The COE would possibly be involved in training local entities and participate in annual exercises to test the system.

NEEDS

COMMUNICATION

The COE Phoenix office is not a direct user of storm data on a real time basis. The COE Phoenix does use NWS forecast information to remain alert to the potential for mobilizing its emergency response or flood fighting capability. The COE Phoenix office has no direct link to the NWS computer system; rather it receives that information via telephone or FAX from the NWS or via modem from the COE Los Angeles office. The COE Los Angeles office does have dial in access to the NWS system.

The COE perceives a need for better communication linkages; phones and FAX have proven unreliable and cumbersome in past experience. It would be desirable to have less time between the time a flood event is declared and the state request for COE emergency response assistance. Improved communications could make the difference in allowing for adequate lead time to mobilize and be pro-active in flood fight efforts instead of responding remedially in emergency situations.

DATA NEEDS/PROBLEMS

- **Daily Reservoir Operations**
  The COE identified the single most important data need as the daily operations planned by dam operators for all upstream dams. Agencies such as SRP, USBR, CAWCD and COE would all supply release data directly into the Statewide Network so that all parties were aware of daily operations that might impact their own plans. While some of this information might be proprietary in nature, any information supplied to the network would be useful. The COE currently must telephone each agency for such data before formulating operating plans for Painted Rock Dam. Direct access to release information and lake level data would be highly beneficial in supporting the decision making process.

- **Streamflow Data**
  The COE perceives a need for access to real time streamflow data to evaluate inflows to reservoirs. Access to precipitation data in real time is not as critical, but is useful historic data.

- **Redundant System**
  Providing redundancy in the design of data and communications systems of the Statewide Network is strongly recommended by the COE. Redundancy would ensure system continuity in the event that one node of the system was lost.

DESIRED PRODUCTS

The data products the COE is interested incorporating into the Statewide Network include:

- **Dam Release Projections**
  15 to 30 day projection of dam operations, release, lake levels updated daily.

- **Basin-Specific Quantitative Precipitation Forecast (QPF)**
  Summarize the outlook for heavy precipitation within a specific basin.

- **Predictive Hydrographs**
  Precipitation data interfaced with hydrologic modeling component to provide predictive hydrographs.

CENTRAL ARIZONA WATER CONSERVATION DISTRICT

Interview Summary Outline

RESPONSIBILITIES	RESOURCES	CAPABILITIES	NEEDS
MISSION • Central Arizona Project • New Waddell Dam **FLOOD CONTROL** • New Waddell Dam Operations **FLOOD WARNING**	**DATA COLLECTION** • Instrumentation • Access to USGS Data Systems **METEOROLOGICAL SUPPORT**		**DATA/PRODUCT NEEDS** • Lightning Data • Local Rainfall Data • GEOSHED Model

CENTRAL ARIZONA WATER CONSERVATION DISTRICT

Summary of Interview with Brian Henning on 1 September 1994

RESPONSIBILITIES

MISSION

The mission of the Central Arizona Water Conservation District (CAWCD) is to manage the delivery of Arizona's allocation of Colorado River water carried by the Central Arizona Project (CAP) Canal. Implicit in this mission is managing the storage of CAP water in Lake Pleasant through operation of New Waddell Dam on the Agua Fria River.

New Waddell Dam is used to store CAP water which is pumped into Lake Pleasant Reservoir during the winter months for use in customer deliveries during the summer. The reservoir is used for storage of CAP water and Agua Fria River inflows. CAP deliveries are released from New Waddell Dam and diverted through the Waddell Canal into the Granite Reef Aqueduct of the CAP. In addition, a lower lake is used to regulate water deliveries to the Maricopa Water District (MWD) and flood releases into the Agua Fria River below New Waddell Dam.

New Waddell has a capacity of about one million acre-feet, of which 200,000 acre-feet (200 KAF) are reserved for flood storage. The firm yield of the Agua Fria River belongs to MWD, up to their maximum storage allocation of 157 KAF.

FLOOD CONTROL

CAWCD's primary concern with flooding is during long duration winter storms. During these events, runoff inflows can cause the reservoir level to encroach into the flood control space of the reservoir. At that time, they can operate the dam to control flood releases and minimize damage on the Agua Fria River below New Waddell Dam.

The primary interest that CAWCD has in local thunderstorms is the resultant effect on irrigation demand. The flood control capacity of New Waddell is normally sufficient to absorb such events.

Operating policy does not allow CAWCD to make preemptive releases from New Waddell Dam in anticipation of a large storm. Legally, CAWCD may only match releases to inflows when the lake level is in the flood control zone and work the flood control space to minimize downstream damage. The CAP canal is well protected from local inflows due to cross-drainage structures and flooding is not considered a problem.

FLOOD WARNING

When releases are anticipated from New Waddell Dam of sufficient magnitude to contribute significantly to flooding conditions in the Agua Fria River, CAWCD notifies the Maricopa County Department of Emergency Management (MCDEM). Other entities downstream that are sensitive to small increments in river discharge, such as sand and gravel operations and residential properties, are also notified by the MCDEM.

RESOURCES

DATA COLLECTION

CAWCD maintains one weather station at New Waddell Dam. The data collected includes precipitation, wind speed and direction, solar radiation and evaporation. In addition, CAWCD can access ALERT station data.

For upper basin monitoring, CAWCD uses the USGS gage network and data collection system. During large events, they typically log onto the USGS computer system and monitor these gages directly. The interface to the USGS computer system is text only. CAWCD uses one of the USGS streamgages for daily water operations and water accounting in Lake Pleasant reservoir.

METEOROLOGICAL SUPPORT

CAWCD has no internal meteorological support. Potentially, the District could receive a NEXRAD feed within the next few years. They could use NEXRAD information as a water management tool for anticipating adjusted water deliveries or tracking storm events which could affect remote equipment and communications. CAWCD uses the National Weather Service forecasts and the Colorado Basin River Forecast Center (CBRFC) for Lake Pleasant watershed modeling.

NEEDS

DATA/PRODUCT NEEDS

The greatest weather related problems with the CAP canal are due to loss of telemetry and control because of lightning strikes or severe storm events. CAWCD would be interested in this data in order to better manage maintenance problems on their canal telemetry. They would be interested in accurate local rainfall data in order to predict irrigation demand.

CAWCD is interested in the use of the GEOSHED model in conjunction with HEC-1 for their own use in Lake Pleasant watershed modeling should communications with the CBRFC fail.

ARIZONA DIVISION OF EMERGENCY MANAGEMENT

Interview Summary Outline

RESPONSIBILITIES	RESOURCES	CAPABILITIES	NEEDS
MISSION • Response • Recovery • Mitigation	**DATA SYSTEMS** • Weather Network • EOC Automation System	**EMERGENCY RESPONSE** • Emergency Operations Center (EOC) • Search and Rescue • Assistance to County Emergency Operations • Plans and Training • REP Response and Recovery • Hazardous Materials	**DESIRED PRODUCTS** • Hydromet Data Products - Long-range forecast - Site-specific QPF - Dam break analysis **COMMUNICATION**

ARIZONA DIVISION OF EMERGENCY MANAGEMENT

Summary of Interview with Harry Border on 22 September 1994

RESPONSIBILITIES

MISSION

The Arizona Division of Emergency Management (ADEM) is responsible for preparing for and coordinating emergency services which may be required to reduce the impact of a disaster on the people and property in the state. Disaster is broadly defined to include national security, technological and natural disasters.

- **Response**
  Emergency response by the ADEM can only occur under certain conditions. During a non-declared emergency, ADEM can only respond to direct life threatening situations.

  When a local governmental entity has utilized all its own emergency response resources, it may request that the Governor declare a state of emergency thereby mobilizing the ADEM to assist in the response effort. ADEM coordinates other state and county emergency response agencies in providing support items or acquiring equipment needed to accomplish the response mission.

- **Recovery**
  A federal disaster declaration makes the governmental entities, businesses, and individuals eligible for federal disaster relief and emergency assistance. This frees up federal funds to assist in the reconstruction and repair of infrastructure damaged as a result of the disaster. FEMA coordinates this effort with ADEM.

  A state declaration allows for the disbursement of state funds in response to requests for assistance by local entities.

- **Mitigation**
  ADEM actively pursues disaster mitigation through continuing education, training programs and in the development of emergency operations plans.

RESOURCES

DATA SYSTEMS

- **Weather Network**
  ADEM provided funding to the NWS to install a computer system to disseminate text and graphical NWS products to ADEM and all 15 counties in Arizona. This provides for one-way communication of NWS products to the counties via dial-in modem link.

At the present time, the program has been implemented in Yuma and Maricopa Counties, with the other counties still to be trained in selecting and using the NWS text products. Graphical products, including satellite imagery, will also eventually be available. Hardware upgrades are needed to fully realize the network's goal of enabling county emergency services agencies direct access to a full menu of weather information products.

- **EOC Automation System**
  ADEM is currently upgrading the Emergency Operations Center (EOC) Automation system. The new emergency information system includes the use of Geographic Information System (GIS) and relational database software.

  The goal of the system is to create a centralized clearinghouse of statewide GIS map data with overlays depicting hydrologic features, economic assets, population centers, natural resources, etc., to enable fact-based emergency management decisions to be made. It is envisioned that this database will constantly be evolving to include new data and capabilities.

CAPABILITIES

EMERGENCY RESPONSE

An important aspect of ADEM's role as statewide emergency response coordinator is the activation of an EOC. The EOC is manned 24 hours per day during declared emergencies to monitor response efforts and gather intelligence from other agencies. Since the ADEM does not maintain in-house technical expertise, the participation of the other agencies provides the technical data necessary to make factual emergency management decisions. Those agencies involved in EOC activity may vary given the nature of the emergency, but commonly include the ADEM, ADWR, ADOT, DPS, ASLD, Health Department, DEQ, AG, NWS, National Guard, Red Cross, amateur radio operators and utility company representatives.

Additionally, ADEM aids the Sheriff's Office in search and rescue missions. ADEM is the primary response agency in the event of an incident at Palo Verde Nuclear Generating Station. They assist counties or other local entities in the development of emergency operations plans and provide training as well.

NEEDS

The ADEM is unique in that their interest in a Statewide Network is not only focused on the flood warning capability. Since they respond to all types of emergencies, extreme weather of any sort is of concern. Not only rainfall, but intense heat, cold and/or wind can have major impacts on a response effort.

DESIRED PRODUCTS

The ADEM does not maintain an in-house technical expertise and, therefore, are more interested in value-added data products on a Statewide Network rather than uninterpreted raw data.

- **Hydromet Data Products**
  - ADEM would like better long range weather forecasts packaged in an easily understood format.

  - A basin-specific QPF would aid greatly in facilitating the assessment of an impending storm to make decisions regarding the intervention necessary to protect life and property.

  - Dam breach or failure causes sudden surges in water surface elevation downstream. A dam break analysis, delineation of inundation areas, and response plan for specific sites is needed. That data presented in graphical format would be useful on the Statewide Network.

COMMUNICATION

ADEM needs a NWS representative at the EOC. If personnel are not available, a communication link is required.

STATE CLIMATOLOGIST FOR ARIZONA

Interview Summary Outline

RESPONSIBILITIES	RESOURCES	CAPABILITIES	NEEDS
MISSION • Research • Education • Service	**DATA ARCHIVE** • NOAA • Special Data Sets - various entitites • Special Data Sets - grants, contracts • Special Data Sets - access to entities • PRISMS • No ALERT data **FUNDING SOURCE** • Arizona State University • Other	**DATA MAINTENANCE** • Quality Control • Archive **ALTERNATIVE USES** • Educational • Applied to entities	**FUNDING** • Computer Systems • Staff • QC Programs

STATE CLIMATOLOGIST FOR ARIZONA

(Office of Climatology, Department of Geography, College of Liberal Arts and Sciences, Arizona State University)

Summary of Interview with Tony Brazel and Sandra Brazel 20 October 1994

RESPONSIBILITIES

The Phoenix National Weather Service office housed a State Climatologist up to 1973, but that function was cut from the NOAA budget. State government, in association with Arizona State University, formed the then Laboratory of Climatology to maintain this function. Subsequently the name of this unit was changed to the Office of Climatology and is now within the Department of Geography at Arizona State University. Through a Memorandum of Agreement, the Office is provided resources necessary to perform the State Climatologist duties. The Agreement is among the Arizona Board of Regents, National Climatic Data Center, and the National Weather Service Western Region. The State Climatologist, Anthony J. Brazel, functions within the Office of Climatology. There is a half-time Director of the Office of Climatology, Robert C. Balling, Jr. The Office has no real-time response role during flood emergencies.

MISSION

- **Research**
  The State Climatologist performs analyses on historical and near real-time weather and climate data. Affiliated staff are a resource in assisting in research and issues of the state network of weather and climate information. For example, a current research project through a grant with the Western Regional Climate Center focuses on the characterization of the Southwest monsoon and possible methods of long-range climate forecasting of the monsoon.

- **Education**
  The State Climatologist is a resource for information on weather and climate that is requested by schools, private individuals, public agencies, journalists, students, faculty, and researchers world-wide. These requests often require education on use of the information and the nature of desert environments such as ours. In conjunction with the National Severe Storms Laboratory, National Weather Service, and Salt River Project, an educational Arizona Thunderstorm Chasers (AZTC) program is offered each summer. The Department of Geography maintains a meteorology/climatology undergraduate emphasis program. Personnel at the Office are engaged in a host of educational related activities from interactions with various museums, K-12 teacher requests, and others.

  The State Climatologist sees major educational possibilities from the development of a statewide interactive network.

- **Service**
  Archiving of information is one of the major duties of the State Climatologist. The State Climatologist serves individual clients, large companies, and agencies in providing data and information and may also provide assistance with expert witness

identification that may involve technical interpretations and issues related to extrapolation of weather and climate data. An additional service of the Office of Climatology is the maintenance of a monthly publication for the past 20 years called The Arizona Climate Summary. This publication contains preliminary data from over 30 National Weather Service cooperative and first order stations as well as reports from the volunteer Arizona Weather Watchers. The State Climatologist is part of the American Association of State Climatologists, a group which considers national issues of the climate data base and maintains connections with NOAA and the regional climate centers regarding policy and federal funding.

RESOURCES

DATA ARCHIVE

The State Climatologist and the Office of Climatology maintains the following data collections:

- World, national, and state level climate data from NOAA sources on various media provided under the Memorandum of Agreement.
- Special state data sets provided by private individuals, companies, federal agencies, and researchers.
- Special data sets purchased through grants and contracts for specific purposes.
- Special data access for requests or projects from sources such as AZMET, Western Regional Climate Center, National Climatic Data Center, Climate Prediction Center.
- Phoenix Real-time Instrumentation for Surface Meteorological Studies (PRISMS), quality control and archive function in coordination with National Weather Service, National Severe Storms Laboratory, and Salt River Project. Currently, a small contract with SRP maintains this program.
- No ALERT data are included in the data collections.

FUNDING

The Office of Climatology is funded through the Department of Geography and the state university budget and through various grant and contract opportunities. Personnel in the Office consist of a full-time secretary, half-time Director, half-time academic professional, and half-time research associate.

CAPABILITIES

DATA MAINTENANCE

The only data set that currently is quality controlled in the Office is the PRISMS data. The State Climatologist receives this information via dedicated telephone line at 5-minute intervals from 17 PRISMS stations located in the Phoenix area. The data are quality checked and flagged as needed and then archived. Through an agreement with SRP the Office of Climatology can disseminate these data, on a fee schedule, to outside entities.

The State Climatologist, given resources, is willing to consider expanding archival and quality control responsibilities to include other environmental data. This would require consultation on the quality control of additional data on the Statewide Network.

ALTERNATIVE USES

The State Climatologist perceives additional uses of a Statewide Network to be increased educational opportunities in the pre-collegiate and collegiate environment through cooperative efforts in the state that would involve special opportunity programs such as NSF Earthstorm. Additionally, a host of interests related to energy, water, air quality, recreation, tourism, ecology, etc., would find the climate and weather data useful for a large range of applications and educational use.

NEEDS

FUNDING

The State Climatologist would require funding for additional computing capability and staffing to accomplish an expanded archiving and quality control function for the Statewide Network. Input from other agencies would be solicited to determine effective and efficient methods for a quality control program of the hydrometeorological data on the Statewide Network.

Tier 2 User Group Interview Summaries

Federal Agencies
- Bureau of Indian Affairs
- USDOT Federal Highway Administration

State Agencies
- Arizona State Parks
- Arizona Department of Transportation - Traffic Operations Center

Counties
- Maricopa County Department of Transportation
- Maricopa County Department of Emergency Management
- Maricopa County Sheriff's Office
- Coconino County
- Apache County
- La Paz County
- Gila County
- Yavapai County
- Pinal County
- Graham County
- Yuma County
- Cochise County
- Greenlee County
- Navajo County
- Santa Cruz County
- Mohave County

Municipalities
- City of Phoenix
- City of Tucson
- City of Scottsdale
- City of Peoria

Rural Communities
- Bullhead City
- Clifton
- Duncan

Federal Agencies

BUREAU OF INDIAN AFFAIRS (BIA)

RESPONSIBILITIES

The Phoenix Area Office of the Bureau of Indian Affairs (BIA) is responsible for the safety of 107 BIA and tribally-owned dams located on five Indian reservations in the State of Arizona, including 19 high or significant hazard structures. The Phoenix Area Safety of Dams Coordinator provides technical support and guidance to tribal leaders and BIA field officials on the operation, maintenance, and general safety of these dams, and with the development and implementation of emergency action plans.

The Phoenix Area Safety of Dams Coordinator also provides technical support and guidance to tribal leaders on floodplain management issues. In an attempt to eliminate or substantially reduce flood related loss of life and property damage, the Phoenix Area Office is promoting the adoption and implementation of sound floodplain management practices and regulations on all reservations under its jurisdiction, and the enrollment of reservation communities in the National Flood Insurance Program. The adoption and enforcement of floodplain regulations is the responsibility of the individual tribal governments. Currently very few reservations in the State of Arizona have any floodplain management or regulation programs, and there is virtually no floodplain delineation mapping on the reservations.

RESOURCES

BIA is currently evaluating the installation of automated Early Warning Systems (EWS) as a means of improving public safety at many of its dams, until funds become available for costly structural modifications and repairs. Presently, an automated EWS is in place and operating at Coolidge Dam on the San Carlos Reservation, and the installation of an automated EWS network for Elgo and Tufa Stone Dams (also on the San Carlos Reservation) is underway. BIA is also conducting a feasibility study for the installation of an EWS network covering nine high hazard dams on the Fort Apache Reservation. Many BIA Early Warning Systems include remote precipitation and streamflow gages, used to predict reservoir inflow. The Elgo/Tufa Stone network will include 14 such remote data collection stations.

CAPABILITIES

While it is BIA's intent that its Early Warning Systems be ALERT compatible, the data produced by those systems may or may not be available to the Statewide Network, depending upon the wishes of the individual tribal governments upon whose reservations the systems are located. These decisions will be based upon on-going water rights litigation and other legal and cultural issues. The Statewide Network administrator will have to work with the individual tribal governments to resolve these issues and to obtain permission to access EWS precipitation, streamflow, and reservoir status data.

BIA's Phoenix Area Office would probably be the focal point for flood warning information received from the Statewide Network, and would be responsible for distributing that information to reservations throughout the state.

NEEDS

In view of the numerous dams on reservations and the dam safety responsibility of the BIA, there is the desire by the BIA to participate in the Statewide Network. Supplemental needs exist for monitoring of the snow-line level, and for QPF and river forecasting with snowmelt. Snowmelt runoff coupled with rainfall is a major flood producing condition on many of the reservations.

USDOT FEDERAL HIGHWAY ADMINISTRATION (FHWA)

RESPONSIBILITIES

The FHWA's primary role in flood emergencies is to provide financial assistance to State and local highway agencies which suffer damage to streets, highways and bridges under their jurisdiction which are eligible for Federal-aid Highway Program Funding. Essentially, all streets and highways are eligible except those functionally classified as rural minor collectors or local roads and streets. FHWA has no specific flood warning responsibilities.

RESOURCES

FHWA relies primarily on telephone (FTS and local networks), computer network links and direct face-to-face meetings and contacts for communications during flood emergencies. They do have a FHWA Emergency Radio System, but it is set up for national emergencies (civil defense, etc.) and is used very infrequently.

CAPABILITIES

FHWA's flood response role includes the following activities:

- Initial assessment of damage
- Preparation and submittal of a Field Report
- Determination that an Emergency Relief Program is warranted
- General authorization of emergency operations and repairs for all sites subsequently determined to be eligible
- Detailed damage inspections
- Eligibility determinations for specific sites
- Technical assistance in the development of appropriate permanent restoration projects
- Authorization of permanent restoration projects
- Final inspection of completed emergency repairs and permanent restorations
- Reimbursement of State and local highway agencies for all eligible costs incurred as a result of the flood emergency

NEEDS

In assessing damage and preparing the field report, FHWA has a need for data regarding the flood magnitude and extent.

State Agencies

ARIZONA STATE PARKS

RESPONSIBILITIES

Arizona State Parks (ASP) has no direct role during flood emergencies. The flood warning function within state parks is usually handled by the Sheriff's Office of the county the park is located in. Park rangers are certified law officers and can assist as well.

RESOURCES

ASP has begun to install ALERT compatible gages at several locations statewide to collect stage data and diversion data to support their water rights claims work. The streamgage locations are Queen Creek, Oak Creek, Verde River, Patagonia, and Pine Creek. These data are not currently transmitting to the ADWR base station, but that capability does exist.

CAPABILITIES

ASP enhanced its data collection program at the Queen Creek and Oak Creek sites by creating environmental education displays adjacent to those gages. The displays show the current readings and the recent hydrographs with explanations about the data, equipment and uses.

NEEDS

ASP's data needs to accomplish their water rights work are well supported by the instrumentation they are installing. They do not perceive a need for additional data.

ARIZONA DEPARTMENT OF TRANSPORTATION (ADOT)
TRAFFIC OPERATIONS CENTER

RESPONSIBILITIES

The ADOT Traffic Operations Center's primary role during flood emergencies is to disseminate road condition information to the local media and to the general public. ADOT maintenance crews are responsible for setting up barriers where state highway road closures result from flooding conditions.

RESOURCES

ADOT complies roadway information gathered from several sources. They maintain constant contact with the Department of Public Safety Highway Patrol for state highway information from patrol officers. Similarly, ADOT receives some county and local roadway information from the Sheriff's Office and local police departments, respectively. This information is communicated by telephone and/or radio. ADOT maintenance crews also report to the Traffic Operations Center information about flooding conditions and the resultant impact on state highways.

CAPABILITIES

ADOT is able to monitor weather conditions by accessing the weather report on the Internet and listening to NOAA Weather Radio. An additional source of data newly available to the Traffic Operations Center is the ALERT gage network owned and operated by the Flood Control District of Maricopa County (FCDMC). While not yet tested, ADOT plans to access this database during flood events to provide ground truth to weather reports and observations received from their other information sources. ADOT does not have access to the USGS gage database.

NEEDS

Recent experience during the floods of January and February 1993 indicated a need for a direct communication link with the NWS Phoenix NWSFO for accurate and timely weather information and forecasts. ADOT is also interested in access to NWS graphical products, satellite imagery and radar products for monitoring storms tracking across the state. Finally, ADOT perceives a need for predictive hydrographs on the Statewide Network to provide better information about the magnitude of peak river discharges and when to expect those peaks to occur.

MARICOPA COUNTY DEPARTMENT OF TRANSPORTATION (MCDOT)

RESPONSIBILITIES

The MCDOT's primary role during a flood event is emergency response. They currently receive notification of flood warning from the FCDMC and mobilize to set up barricades, reroute traffic, pump ponding areas, etc. They are in the process of installing a base station in-house for direct access to the ALERT rain and stream gage data. By having the ability to monitor real-time hydrometeorological data and radar products, they seek to be more proactive, less reactive in eliminating the hazards of flooding associated with county roadways.

RESOURCES

MCDOT generates no hydromet data, but is an end user of that information.

CAPABILITIES

MCDOT receives prewarning from agencies operating dams regarding dam releases. Combined with direct access to rain and stream gage data and radar products with the base station, MCDOT will have the capability to make data-based decisions and increase lead time in implementing their flood response plans.

NEEDS

With the installation of the ALERT base station, MCDOT has ready access to the real-time data needed to support their flood response role. The data products desired by MCDOT on the Statewide Network include additional ALERT data outside Maricopa County, storm track graphics, and a spreadsheet of projected dam releases.

MARICOPA COUNTY DEPARTMENT OF EMERGENCY MANAGEMENT (MCDEM)

RESPONSIBILITIES

During a flood emergency, MCDEM's primary responsibility is flood warning. County agencies, municipal governments and the public are kept informed of the emergency by the duty officer or through the Emergency Operations Center.

MCDEM receives flood warnings directly from the NWS. During normal duty hours, MCDEM has the capability to monitor and record NWS notifications on the National Warning System (NAWAS) radio. Changes in the notification procedures have been implemented for after normal duty hour and weekend duty officers. Past procedures using a relay from the Sheriff's Office were not always timely. The MCDEM duty officer is now notified directly by the NWS so that the timeliness of notifications should improve.

RESOURCES

MCDEM does not generate hydrometeorological data or data products rather is an end user of that information.

CAPABILITIES

MCDEM prepares for and coordinates emergency services which may be required to reduce the impact of a disaster on the people and property in Maricopa County.

NEEDS

MCDEM is dependent on flood-related data to ensure the safety of people and protection of property. In that context, it is necessary to have any related data on flooding particularly if evacuation of threatened areas is required. Inundation areas drive the decision for relocation and adequate lead time is needed to effectively perform that function. Obviously, timely reporting of weather information, precipitation, stream gage data, and dam releases is needed for sound decision making.

Of greatest need by the MCDEM is accurate inundation studies, particularly downstream of flood retarding structures and dams in the event of catastrophic failure. The lack of accurate inundation mapping of the Gila River downstream of Coolidge dam was of great concern during the floods of 1993. A hydrologic modeling component in the Statewide Network would be a useful tool for the MCDEM by providing the capability to model flood inundation areas and graphically depict areas in jeopardy through the use of the GIS system. Using real-time precipitation data as input to the model, flood magnitude and inundation areas could be determined thereby providing the information and lead time necessary to make data-based decisions in implementing emergency response plans.

MARICOPA COUNTY SHERIFF'S OFFICE (MCSO)

RESPONSIBILITIES

The MCSO's primary role during flood emergencies is to relay information regarding flood hazards by their personnel in the field and by citizen observers to other county departments; primarily the MCDOT, MCDEM, and FCDMC. Sheriff Deputies in the field report via radio to the communications center at MCSO; field personnel do not directly contact other county departments. Depending upon the nature of the flood emergency reported, the central communications dispatcher will initially relay that information by telephone to other appropriate county departments for emergency response (i.e. erecting barricades, road closures, etc.). After aforementioned county departments are activated, additional information regarding flood hazards is relayed and coordinated by radio. If a Deputy observes a situation requiring immediate action, the MCSO will direct evacuations. It is more common, when adequate lead time exists, for evacuations to be ordered by outside entities rather than by the local deputy. Again, MCSO will assist with those evacuations.

RESOURCES

The MCSO monitors the NOAA Weather Wire, NAWAS, Civil Defense Radio, and Interagency Radio for information including flooding emergencies. When a severe event threatens Maricopa County in particular, the NWS may request acknowledgement from MCSO that the broadcast has been received. MCSO will, in that case, acknowledge receipt of the message and contact the MCDEM Duty Officer. The MCSO's mission is primarily law enforcement and they do not have in-house technical expertise to interpret hydromet data. They do not have computer access to the FCDMC's ALERT or other hydrologic databases.

NEEDS

The MCSO currently receives an adequate information flow relative to flood emergencies to carry out its mission. They do not perceive a need for hydromet data, satellite imagery or radar products. They would not have the in-house expertise to interpret technical data and prefer to rely on outside agencies to do so. They do perceive a need for a documented Flood Warning Plan which clearly identifies a list of who to contact for different levels of flooding hazards, (i.e. street flooding, riverine flooding, flooding associated with flood control structures, etc.). In the past, relay communications with other departments have been haphazard; a definitive response plan is needed.

COUNTIES

Of the 15 counties in Arizona, 13 of them (all but Maricopa and Pima) share many of the same characteristics in regard to emergency response to floods. Because of the shared commonality by each of those 13 counties, those counties are discussed as a group. Following the general discussion, county-specific issues related to flood warning are presented.

RESPONSIBILITIES

Emergency management response, including flood warning, is conducted by the county emergency services, usually in conjunction with the public works department, county sheriff's office and/or a fire district chief. Flood watches and flood warnings by the NWS are directed to one of those agencies, which then coordinates with the other agencies. Response to flooding or potential flooding consists of any or all of the following actions; road closures by the sheriff's office or local police departments, emergency life support services by fire departments, dispatch of road maintenance crews to known or reported problem areas, and action by the county flood control district in the event of flood emergency response.

RESOURCES

Resources for flood warning are generally limited. Other than notices of flood watches and flood warnings as issued by the NWS, counties generally rely on reports by the county sheriff, by road maintenance crews, or other county agencies with personnel in the field to report flooding situations. Flood warning, per se, generally does not exist in these 13 counties, and flood response is generally reactive to flood occurrences. A few counties have initiated flood monitoring programs for selected watersheds that are deemed to be particularly hazardous and/or life threatening. Specifics of county flood monitoring programs are provided in the county-specific comments.

CAPABILITIES

The 13 counties are generally well qualified to respond to flood situations through the county emergency services, county flood control district, sheriff's office, and fire districts. However, those counties generally have little established capability in regard to flood warning. Where flood warning roles are being pursued, they are generally within the county flood control districts.

NEEDS

The perception of needs for flood warning varies considerably among the 13 counties, and range from expression of no strong need to vigorous planning for implementation or participation in the Statewide Network. Because of this disparity, the perceived need for flood warning is contained as a county-specific comment for each county.

COUNTY-SPECIFIC COMMENTS

Coconino County

- An ALERT system is in use in the Oak Creek area. Yavapai County participated in funding the installation and contributes half of maintenance cost. That system consists of 4 streamgages, plus 13 raingages in the Sedona area.
- The Oak Creek ALERT system did not provide flood warning because flooding was caused by rain coupled with snowmelt.
- NWS information is sent to the sheriff's office.
- The County will probably not pursue an active flood warning posture because of budget constraints. This situation could change in the future.

Apache County

- NWS information is sent to the sheriff's office; this is coordinated with emergency services if the need arises.
- Flooding is usually reported by the sheriff's office and by county road maintenance crews.
- Flooding is usually caused by snowmelt.
- Winter storm warnings would be beneficial so that road maintenance can be planned.
- Improved flood warning is not perceived as a strong need.

La Paz County

- NWS information is sent to the emergency services director at the Buckskin Fire District.
- Flow in the Colorado River is well regulated. More than adequate lead time is available between notification of high flows in the river and implementation of flood response plans.
- La Paz County perceives a need for improved warning for summer thunderstorms of high intensity and short duration. These storms cause flash floods in normally dry washes.
- The Sheriff's Office and DPS mobilize to barricade and close roads where they cross washes at dip crossings during flash floods. Trouble spots are well known based on past experience.

- Bouse Wash at Highway 72 and Tyson Wash at Quartzsite are two areas of flooding concern. FEMA is undertaking a detailed study of Tyson Wash to assess flood hazard to existing developed areas.

- Regulated flows released from Alamo Dam into the Bill Williams River have caused damage to roads and property. Communication has been inadequate on this issue between flow regulators and county officials.

- La Paz County supports a Statewide Network and perceives a need for improved flood warning.

Gila County

- The 1993 floods indicated the need for a flood warning system.

- Gila County will be installing an ALERT system.

Yavapai County

- The Yavapai County Flood Control District views flood warning as a service that it should provide.

- The District does not receive NWS information because of modem linkage problems. It relies on information by informal contact with the Flood Control District of Maricopa County.

- Yavapai County would like direct access via the Statewide Network to data bases compiled by other agencies such as the USGS, SCS and USFS.

- The County has instrumentation in the Prescott area consisting of 10 raingages and 3 stage gages. The county also receives data for the Oak Creek system in Coconino County.

- There is concern that the Yavapai County system is referred to as a flood warning system, but it only serves as data collection.

- There are serious equipment problems with both the Prescott and Oak Creek systems. The repeater for the Oak Creek system is unreliable. The major problem is that instruments consist of intermixed components from various vendors. This has resulted in the inability to adequately maintain gages.

- There is currently no completed watershed model for the Prescott system. Data has been collected by ADWR and work is in progress on the model.

- There is no confidence in data that is obtained.

- Alternative uses of the system would be winter storm warnings and for NPDES monitoring.

- Yavapai County has strong interest in a flood warning system and perceives this as a need.

- Yavapai County has noted an increased level of response by ADWR following the establishment of the Flood Warning Office and subsequent increase in staffing.

Pinal County

- The Pinal County Department of Civil Works is responsible for flood response.

- Emergency services were conducted by the County Special Services Department prior to the 1993 floods. Emergency Services is now within the Department of Civil Works.

- Instrumentation had been installed in McClellan Wash consisting of 1 raingage and 3 streamgages. Those gages did not function during the 1993 floods, and have since been dismantled. The need to re-establish these gages will be re-evaluated in the future.

- Major flooding during 1993 principally occurred on the San Pedro, Gila, and Santa Cruz Rivers and Aravaipa Creek. USGS gages on the San Pedro and Gila Rivers were monitored by Pinal County as well as Dam Discharges from the Coolidge Dam Reservoir. However, most of the USGS gages became inoperative during the flooding, significantly limiting their usefulness. Limited information was available concerning flood discharges on the Santa Cruz River through coordination with the Pima County Flood Control Department.

- Urban flooding of low-lying communities along the rivers and major streams is a concern of the County.

- Alternative uses are weather information for agricultural use including management of irrigation systems and applications of herbicides.

- Pinal County perceives a need for flood warning so that useful information is available for appropriate emergency management decisions.

- Ideally, the Statewide Network would not only provide warning in terms of flow rates, but also provide mapping presentations which project anticipated geographic flood areas and time frames in which flooding would occur.

Graham County

- The major cause of flooding problems in Graham County are general winter storms of long duration in the following watersheds: Gila River, San Simon River, Ash Creek, Aravaipa Creek, Eagle Creek, Bonita Creek, and Stockton Creek.

- Some flooding in smaller drainage areas results from summer thunderstorms. It is unlikely that adequate flood warning could be provided in these areas due to the relatively short lag time in basin response.

- Flood retarding structures constructed to protect the towns of Thatcher and Safford from runoff from the south (Mt. Graham) function well to minimize damages in these areas.

- Structural flood control solutions to flood problems along other drainages have not proven to be cost justified; therefore, adequate flood warning is needed. These washes include: Cottonwood Wash and Ash Creek in Pima, Black Rock Wash in Ft. Thomas, and Maryhilda Creek and Stockton Wash draining Mt. Graham.

- Warm rain on snowpack on Mt. Graham can cause increased runoff in some basins. The County Engineer uses SCS SNOTEL reports to interpret potential impacts to the runoff characteristics of the mountain basins.

- Graham County perceives the need for more basin instrumentation, especially in the San Simon River basin and Sulphur Springs Valley north of Wilcox.

- Graham County would like direct access to more real-time gage data via modem hookup to the USGS data system. There is a concern that data be reported in useable format (i.e. stream gage readings in cfs rather than gage height).

- Data products that would be useful to Graham County in monitoring and responding to flood emergencies were identified. These include radar products, especially for use in monitoring summer thunderstorms, and predictive hydrographs from hydrologic models forecasting flows and time to peak at various points along a river.

Yuma County

- Yuma County has no flood warning system at this time. No hydrological data is generated by the County.

- The major sources of flooding in Yuma County are the Colorado River and the Gila River.

- During significant river flows, it is helpful to have daily information from the Bureau of Reclamation and the Corps of Engineers on dam releases upstream on the Colorado River and Gila River, respectively. By having an idea of the magnitude of the dam releases, the Public Works Department can make operational decisions regarding roads and bridges and County Emergency Services can plan accordingly.

- Flooding from the rivers traversing Yuma County affects many agencies at the federal, state and local level. During the 1993 Gila River flood, it was advantageous to operate two command centers; one near Wellton and one in Yuma, Arizona.

- Important data needs for Yuma County are to have data on the status of upstream dam releases and to have advance notice of adverse weather conditions.

- A desired data product is a matrix type spreadsheet showing releases of upstream dams on both rivers, input and output into downstream reaches and other information.

- Standard fax machines seem adequate for river information. It should be updated and sent daily.

- Better forecasting and notification of adverse weather condition to area agencies is needed. This information should be sent as soon as possible to all affected agencies.

- Irrigation districts also need adverse weather condition information so irrigation systems can be shut down and drainage systems can be energized. Whether this information is sent directly to each entity or to a central point in Yuma County and then disseminated, needs to be determined and developed.

Cochise County

- Alluvial fan flooding accounts for the majority of flooding problems in Cochise County. Typically, flooding occurs along divergent, undefined washes which drain small watersheds with a relatively short basin response time. The washes draining the Huachuca Mountains near Sierra Vista are of this type.

- Riverine flooding along the San Pedro River is rare as the river channel is well incised to contain the 100-year discharge. Riverine flooding along the tributaries to the San Pedro River, such as the Babocomari River, does occur during long duration winter storms.

- Both summer thunderstorms and general winter storms can cause flooding problems in alluvial fan and riverine areas within Cochise County's jurisdiction.

- No hydrological data is generated by Cochise County; however, the ARS maintains a watershed monitoring system for research purposes at Walnut Gulch. Cochise County does not have direct interface to the Walnut Gulch data.

- Cochise County does not perceive a need for real-time flood data, radar products, or satellite imagery beyond what is currently available. The County does not have the personnel available at this time for interpretation and analysis of additional data.

- Alternative use of a Statewide Network would be the collection of historic data for use in calibrating hydrologic models to aid in floodplain management.

- The COE is studying the feasibility of installing a FWS in the Sulphur Springs Valley north of Wilcox, Arizona. Cochise county expects the Corps plan to be implemented in 1-2 years.

Greenlee County

- The major sources of riverine flooding in Greenlee County are the Gila River, San Francisco River, Blue River and Eagle Creek.

- General winter storms cause the majority of significant flooding in Greenlee County. High intensity storms typical of summer thunderstorms can occur in winter months as well. Because of the terrain, precipitation amounts and intensities can vary significantly across a basin.

- Greenlee County receives no regular communication from the NWS. The County will often initiate contact with the NWS as a storm approaches to request forecast information. The Sheriff's Office contacts citizen observers in remote areas to obtain current weather and/or streamflow observations. Historically, there have been communication failures with resultant gaps in vital information. False positive can be problematic.

- Greenlee County does not own or operate any gages. The major rivers traversing the County drain watersheds extending across the state line into New Mexico. In order for the data from a Statewide Network to be useful to Greenlee County, it is imperative that the system encompass data from gages located in that portion of the watershed extending beyond the state line.

- Greenlee County does not perceive a need for access to NEXRAD products or satellite imagery. This requires training County personnel not currently available in interpretation and modeling.

- Data needs important to Greenlee County are additional, dependable rainfall and streamflow gages contributing more reliable and quality controlled data to a data system.

- Desired data products include predictive hydrographs models using real-time precipitation data. The County staff has a very good sense of the impacts to their jurisdictional floodplains resulting from different magnitudes of river discharge. They can respond appropriately given a streamflow forecast.

Navajo County

- The major sources of flooding in Navajo County are the Little Colorado River at Winslow and Holbrook, Silver Creek/Cottonwood Wash at Taylor and Snowflake, Show Low Creek, Leroux Wash and Rio Puerco.

- Most flooding is riverine in response to general winter storms of long duration. Summer thunderstorm activity can produce very localized subdivision flooding.

- Communication of flood information is via telephone and radio. Navajo County can access the NWS data System via modem. The County monitors NOAA Weather Radio and will call the NWS Winslow office for weather forecast information, as required.

- The Public Works Department and County Emergency Services together disseminate flood information to other county offices, including the Sheriff's Office. Road crews are dispatched as needed.

- A general emergency response plan exists, but a perceived need is for a more basin-specific flood warning plan.

- Navajo County currently does not own or operate any gages. Manual monitoring of streamflow and reservoir levels can be problematic during flood events. They are in the process of implementing an ALERT System. Installation is expected to begin in about 2 months.

- Navajo County does have the in-house capability to conduct hydrologic/hydraulic analyses of data. They perceive the need for more real-time data for their use as input to hydrologic models to develop predictive hydrographs. Using hydraulic models, they could delineate the resultant inundation areas.

- Navajo County has the in-house expertise to interpret meteorological data such as NEXRAD products and satellite imagery. They do not want to assume responsibility for developing end product information such as QPF; NWS should retain forecast responsibility. Navajo County would use NEXRAD products as visual verification of NWS forecasts.

Santa Cruz County

- The major sources of flooding in Santa Cruz County are primarily riverine, urban washes in the Nogales, Arizona area. These washes include Nogales Wash, Ephraim Canyon (Western Avenue), and Portrero Creek. Flooding along Sonita Creek in Patagonia is also of concern to the County.

- Floodplain management policy along the Santa Cruz River has been effective in minimizing threat to life and property along the reach of the river located within Santa Cruz County. Erosion control is the primary focus.

- Flooding in response to long duration, general winter storms has resulted in the greatest amount of damage in the County. The channels are not adequate to effectively handle runoff due to summer thunderstorm activity either.

- Santa Cruz County does not own or operate any gages. County personnel are assigned to known problem areas during significant storm events to monitor streamflow. They communicate observations to the County Emergency Services via telephone or radio.

- An ongoing study by the COE addresses flood control and flood warning along Nogales Wash. A recent agreement with the government of Mexico will enable the installation of instrumentation in that portion of the watershed across the international border.

- Santa Cruz County perceives a need for more specific quantitative precipitation forecasts (which include the watershed in Mexico), and additional information regarding storm tracks especially during the summer. Information needs to be presented in an easily understood format.

- The County perceives a need for hydrologic forecasts of anticipated discharge resulting from forecast rainfall. These predictive hydrographs could be used to develop a chart outlining emergency action plans to be implemented given a level of water in the channel.

Mohave County

- Mohave County experiences both riverine and alluvial fan type flooding in response to both general winter storms and summer thunderstorms.

- Areas with major flooding problems within Mohave County's jurisdiction include Kingman, Bullhead City, and Lake Havasu City. Other populated centers with flooding problems are areas in the vicinity of Littlefield, Colorado City, Dolan Springs, Sacramento Valley, Detrital Valley, Hualapai Valley, Big Sandy River Valley, and the Colorado River Valley between south of Bullhead City (Mohave Valley) and north of Lake Havasu City (Chemehuevi Valley).

- Historically, there have been problems with channel sedimentation and debris flows in the Lake Havasu City and Bullhead City areas.
- Mohave County does not currently own or operate any gages. They do not directly receive data from BLM or USGS gages in the County.

- Mohave County does have an emergency operations plan for man-made and natural disasters, but it does not specifically address flooding problems. They are in the process of developing a flood response plan.

- A flood warning system is being planned for Bullhead City and Kingman cooperatively by the COE, ADWR and Mohave County. The instrumentation will soon be installed and is expected to be operational by spring 1995.

- Bullhead City currently sends spotters to visually monitor water levels during storm events. They report by radio back to the EOC.

- Mohave County perceives a need for better forecast products such as a basin-specific quantitative precipitation forecast. Because of the short basin response time typical of watersheds in the area, a hydrologic modeling component would not be as effective as forecast products.

- Weather forecasts for Mohave County are the responsibility of the NWS Las Vegas NWSFO. Mohave County anticipates an improvement in weather information once the Doppler radar is installed there.

- Mohave County periodically experiences difficulty in receiving NOAA Weather Radio because of distance and interference. They perceive a need for better radio coverage for northwestern Arizona.

Municipalities

CITY OF PHOENIX

RESPONSIBILITIES

Flood warning functions for the City of Phoenix would mainly involve the offices of Emergency Management and Floodplain Management. For the purposes of discussions about a flood warning system, the Floodplain Management office is the focal point, and that office will communicate with other city agencies.

The City does not presently operate gages or obtain any data. The City had operated a series of raingages which were mainly located at firestations, but those raingages have been turned over to the Food Control District of Maricopa County for operation. An evaluation and analysis of that raingage data is contained in the report Review of Design Rainfall Criteria and Evaluation of Raingage Network, by Tipton and Kalbach, Inc., dated April 1986.

The City had previously investigated a local flood warning system, and the results of that study are contained in the report Phoenix Flash Flood Prediction Program, by Henz Kelly and Associates, dated May 1986. The City did not pursue a flood warning system at that time because there was not a perceived need for the service, and possibly because of concerns over liability that may be associated with providing this service.

RESOURCES

The City of Phoenix, has exceptional resources to participate in a flood warning system. The City is well staffed in the key offices that would participate in the flood warning program. In general, the City is anxious to take advantage of technological advances to provide improved services to its citizen. As an example of this, the City noted that it uses a computerized fire warning system and suggested that it may be possible to integrate flood warning into that system for better emergency response.

CAPABILITIES

The City does not have the capability at this time to provide hydrometeorologic data to the flood warning system. Raingages that had been previously maintained by the City have been turned over to the Flood Control District of Maricopa County for maintenance and operation. The City will probably continue to rely on the Flood Control District to operate and maintain data collection functions within the City. However, the City does have significant other capabilities in regard to flood warning services to the City. These capabilities include a strong and diversified staff, a commitment to using advanced technology to better serve its citizens, and an existing computerized fire warning system that may be able to integrate with flood warning services.

NEEDS

Presently, the City perceives the need for flood warning services and that such a system would significant "spin-off" advantages in regard to overall citizen information service, floodplain management, and local drainage issues. Advance flood warning would be valuable in regard to street closures, deployment of emergency vehicles to areas of imminent threat, to the police department so that motorcycle patrolmen can be reassigned to cars, and for street maintenance such as pumps at known local drainage problems.

Alternative uses were noted to be construction management by the City's project managers, and potentially of use in sewage treatment plant operation. A flood warning system could also provide data that could be useful in the allocation of resources for drainage and flooding problems. In general, a flood warning system could be a common denominator of information that could be used by a wide variety of agencies in the City.

CITY OF TUCSON

The major flood problems within the City of Tucson's jurisdiction are from riverine sources such as the Santa Cruz River, Rillito River, Tanque Verde and Pantano Wash. These normally dry rivers flood in response to long duration, general winter storms with a relatively large lead time. Minor tributaries such as Arroyo Chico can cause urban flooding during high intensity, short duration summer monsoon storms with small response times. Undersized storm drain collectors and arterials quickly reach capacity flow so that roads function as channels and intersections flood as a result of even minor storms.

RESPONSIBILITIES

The majority of the City of Tucson's flood management responsibilities occur before and after a flood. During those times, they are involved in hydrologic studies to help develop response plans. Flood warning is not the City of Tucson's focus. Rather, a Capital Improvement Program funded to approximately $2-3M is used to address and alleviate flooding situations primarily through structural flood control solutions. In this regard, they plan for the construction of flood control structures and they contract for the installation of those structures as budgets permit.

The actual flood warning function resides in the Pima County Flood Control District. During flooding, Pima County monitors the incoming data and directly contacts both the Sheriff's Office and City of Tucson operations crews. The City of Tucson provides emergency services through its Police Department and the street maintenance crews in closing roads, erecting signage, etc.

RESOURCES

The City of Tucson currently gets hydrologic data from the Pima County Flood Control District and from the USGS. It does not directly collect any of its own. In the past, the City of Tucson participated in a joint data collection project with Pima County and the USGS by partially funding basin instrumentation, but that joint effort has stopped.

The City of Tucson is currently involved in a Stormwater Management Study of 59 watersheds in the Tucson area ranging from 500 to 7,000 cfs discharge. The study seeks to identify the watersheds boundaries and discharges using HEC-1 modeling techniques. This study will be used as a master planning tool to analyze the impact of changes in the watershed upon the resultant basin discharge. Part of the contract includes GIS coverages of the study areas.

CAPABILITIES

The City of Tucson has a staff of seven engineers that have the expertise to perform hydrologic and hydraulic modeling to predict the location and severity of flooding. This staff is experienced in deciding where to invest infrastructure improvement money and in helping plan the actions of emergency response crews. This staff is qualified to provide hydrologic support during floods should the City of Tucson and Pima County so desire.

The City of Tucson sees the flood warning system as a basic tool in its new program of monitoring water quality in storm runoff for NPDES compliance. The timely warning of predicted flood events would allow them to get sample collectors on site in advance and improve the quality of the program.

NEEDS

The City of Tucson perceives a need for more timely and more basin specific flood warnings. They are not satisfied with the small lead time they have had in the past to mobilize their emergency services response. They need better access to the data and communication systems of the basin monitoring equipment, possibly a base station for their use.

CITY OF SCOTTSDALE

RESPONSIBILITIES

The City of Scottsdale has made a commitment at the highest level of management to emergency services, including flood response. The duty of Emergency Services Administrator has been assigned to the Police Chief, and in addition, the City has a full-time Emergency Services Director. The responsibility for developing a flood warning and flood response system is being actively pursued by the Emergency Services Director and the Drainage Department. The City is also using the service of a volunteer citizen to assist the City in its flood warning planning. The City is very active in its flood warning planning, and it has expressed the desire to have an improved system for flood warning in operation by the summer of 1995.

RESOURCES

The major resource of the City of Scottsdale in regard to flood warning is its available personnel. That resource consists of a full-time Emergency Services Director, an Emergency Services Administrator, the Drainage Department for technical assistance in flood warning planning, and the volunteer citizen to assist in the development of a flood warning system for the City. In addition, during a flood situation, the City uses the services of the Police Department for flood detection and traffic control, Rural Metro Fire Departments for warning of severe storms in outlying communities in the Phoenix metropolitan area and for emergency life support services, the Transportation Department for barricading of roads and road maintenance due to sediment deposits in streets, the Parks Department for the Indian Bend Wash multi-use facility, and the Water Resources Department for maintenance of water and wastewater lines as needed.

The City is actively coordinating with the Arizona Department of Water resources (ADWR) in regard to installing ALERT gages in Scottsdale, and with the Flood Control District of Maricopa County (FCDMC) for the installation and maintenance of those gages within the FCDMC's county-wide ALERT network. Intergovernmental agreements are anticipated with both ADWR and FCDMC in the near future in regard to these items.

In addition, the City of Scottsdale has a tremendous resource in regard to its GIS capabilities. The City is anticipating using that resource to its fullest potential for flood warning by the Emergency Services Director. The City is also participating with NASA in regard to the testing and development of remote sensing capabilities for urban planning and related data needs. That NASA project could offer potential alternative uses of the hydrometeorologic data network that could provide a demonstration of ancillary uses of the flood warning system.

The City also has numerous hydrologic and hydraulic studies of Indian Bend Wash that are available for incorporating hydrologic and/or hydraulic modeling with severe storm forecasting. That modeling, when combined with the City's GIS capabilities, would make an interesting application of advanced flood warning systems.

CAPABILITIES

The City of Scottsdale's capabilities are extensive due to its rather unique resources for a metropolitan area, and its commitment to providing flood warning services. The City's capabilities are also enhances by its GIS system and the potential for the application of remote sensing information and data through its participation with a NASA project.

NEEDS

The City expressed its desire to move from a flood response reactive mode based on observations of flooding to a proactive mode based on defined levels of severe storm potential. The major need of the City is in regard to its transportation corridors, and the ability of the City to maintain emergency services throughout the City during floods. Indian Bend Wash intersects much of the City and during severe flooding, access to all portions of the City can be interrupted due to high discharges in Indian Bend Wash. The City needs advance warning of flooding so that it can dispatch police, fire, and maintenance crews to various zones within the City so as not to isolate areas from these services. The City is also experiencing rapid growth in the region north of the Central Arizona Project Canal. Major transportation routes in that part of the City convey extensive traffic and those roads are particularly dangerous during severe storms.

Overall, the City's major need is improvement in advance warning of potential flooding events so that the appropriate emergency response can be undertaken prior to the closure of transportation routes. The City sees that need being satisfied by a flood warning system that provides various levels of flood forecasting. The City does not anticipate that it will have the resources or capabilities to provide the basic interpretation of hydrometerologic data, and therefore the City has identified the need for that service to be provided through the Statewide Network or through the independent contracting of the interpretation of the data. The City prefers to develop appropriate flood response scenarios that are based on predefined flood forecast levels that are supplied to the Emergency Services Director.

CITY OF PEORIA

RESPONSIBILITIES

The City of Peoria's emergency response during a flood event is coordinated by the Emergency Response Team from a single location. The police and fire departments conduct rescue operations for stranded motorists and assist in evacuations, as required. The Public Works Department handles road closures, signage and sandbagging. The Engineering Department Coordinates with the other departments to keep roads open and utilities operational. City crews and police monitor the flooding situation in the field. The major flood sources are the Agua Fria River and the New River.

RESOURCES

The City of Peoria has a documented Flood Response Plan that is implemented during events. The Fire Chief serves as the Emergency Operations Center (EOC) Director in the event that the EOC is activated to manage the response effort. The City has access to an array of hydrometerological information sources. Both the Police and Fire Departments receive NOAA Weather Radio. The Police Department receives NOAA Weather Wire and monitors the cable TV Weather Channel. They dial-in to the NWS database to access the standard NWS products.

CAPABILITIES

The City of Peoria seeks to become less reactive and more proactive in flood response efforts. Based upon past experience, the emergency managers have developed a knowledge of the typical storm tracks across the city and the trouble spots that require monitoring during events. Coupled with the data stream they already receive, the emergency response personnel are well positioned to respond proactively before flood peaks thereby saving lives and property.

NEEDS

The City of Peoria does not perceive a need for more data; they rely on the NWS to interpret available hydrometeorological data. The City is satisfied with the specificity of the NWS data products and the communication system in place to disseminate that information. The need to address localized urban flooding problems has driven successful bond issues for major storm drain projects and the construction of bridged crossings for arterial roads where they cross major drainages.

Rural Communities

CITY OF BULLHEAD CITY

RESPONSIBILITIES

The City of Bullhead City (BHC) performs an emergency response role during flood events. BHC receives flood warnings from the NWS Las Vegas NWSFO via FAX to the police dispatcher. The dispatcher notifies all on-call city personnel of flood warnings in the police and other city departments. An Emergency Response Plan is implemented; the City mobilizes its public works department to close roads, erect signage, or perform evacuations as required.

RESOURCES

The City has three engineers on staff involved in infrastructure planning and design. BHC may contact Mohave County if the resources of the City are exceeded in responding to a flood event. ADOT is contacted if major problems related to State Route 95 result from flooding. The City may call on private heavy equipment operators to assist in flood response, if needed. City personnel and citizen observers will contact the City with information about rainfall or flooding. BHC owns or operates no monitoring devices.

CAPABILITIES

The major flooding problems in BHC result from summer thunderstorms of high intensity and short duration. BHC's emergency response team is very experienced in determining when flooding is imminent based on their knowledge of rainfall patterns and the trouble spots for flooding in the local area. They seek to be proactive in emergency response by anticipating flood warnings in advance and mobilizing their response team early.

NEEDS

Due to the watershed characteristics of the basins, a short lead time of about 45 minutes to an hour really limits the emergency managers response capability. They often find themselves in a reactive mode, responding after the flooding has dissipated. More timely flood warning notification would improve the response capability. However, even with adequate notification, the primary source of flood-related problems is the historical lack of floodplain planning in BHC which has resulted in large scale development in flood hazard areas. The City is attempting to alleviate this problem through the remedial construction of flood control structures to protect developed areas and through sound floodplain management.

TOWN OF CLIFTON

RESPONSIBILITIES

The Town of Clifton is responsible for providing emergency services during flooding events. They receive flood warnings from the NWS Phoenix NWSFO and monitor their ALERT gage data on the base station located at the Police Department. The base station has preset alarm thresholds to alert town personnel that flooding is occurring. Police officers also manually read a stream gage located in town on the San Francisco River. The Town of Clifton will directly contact the NWS via telephone for support in hydrologic data interpretation and modeling. The NWS provides forecasts of peak river discharge and the time to peak to the Town of Clifton.

RESOURCES

The Town of Clifton operates and maintains an ALERT rainfall and streamgage data collection system of 11 gages and 3 repeaters. The system is fully installed, but there have been some functional problems. An ongoing COE project in Clifton will alleviate reverine flooding from the San Francisco River with the construction of a levee system through town. The COE plan also involves the relocation of residents from the 100-year floodplain to nearby high ground.

CAPABILITIES

The major flooding source in Clifton is the San Francisco River. Flooding problems result form general winter storms or series of storms. Town crews are responsible for manually closing gates through the levee to prevent backflow from the river into the streets during flood stage. They then open the gates when river flows subside to drain the area behind the levee.

NEEDS

The San Francisco River at Clifton drains an upper watershed extending into western New Mexico. The Town of Clifton perceives a need for more data in that region to facilitate more accurate forecasts of river discharge at Clifton. The Town of Clifton is responsible for operating and maintaining the ALERT network. Additional funding is needed to support the costs of equipment maintenance and possibly added staff to provide in-house expertise in data interpretation.

TOWN OF DUNCAN

RESPONSIBILITIES

The Town of Duncan provides emergency response services during flood events. They receive flood warnings by telephone from the NWS Phoenix NWSFO or ADEM. Other sources of information may also include the Greenlee County Sheriff's Office and local citizen observers. Once notified, the Town of Duncan mobilizes crews to close roads or assist in evacuations.

RESOURCES

The Town of Duncan owns and operates one rain gage. The Gila River is the major flooding source in Duncan, draining a large upper watershed in western New Mexico. The rain gage data collected at Duncan is not indicative of flooding potential on the Gila River as local rain is not of consequence in triggering local flooding on the river during long duration, general winter storms. In an effort to gather information about the status of the watershed above Duncan, the Town has in the past imitated direct contact with the NWS for data and data interpretation. They have also established direct communication with the Colorado Basin River Forecast Center (CBRFC) for support in assessing the forecast river discharge and expected time to maximum flood stage.

CAPABILITIES

Coupled with the support from the NWS in forecasting floods on the Gila River, the Town of Duncan personnel are very knowledgeable about the local flood behavior of the river. Based on past experience, they know what to expect and when. During floods, they actively field inspect the situation on the river, adjusting their emergency response efforts accordingly.

NEEDS

The Town of Duncan perceives a need for more hydrometeorological data, specifically in the upper Gila River watershed in western New Mexico. The experience gained during the floods of 1993 indicates a need for better communication and information flow between the Town of Duncan, Greenlee County, and the State.

APPENDIX E

DATA AND PRODUCT MATRIX

DATA AND PRODUCT MATRIX

This matrix is a working document to help us determine the life cycle of data and products within the Statewide Network. This matrix is one of the tools used in designing the network architecture. The matrix is organized as follows:

- Network node points are listed down the left hand column.

- Data and products are listed across the top row of each page. The data and products are generally organized from farthest out in space and time to most immediate. Thus, the first data column is for satellite observations which are often used to view events several days before they hit Arizona, and the last page concerns stream flow data which is what causes any actual damage.

- The field cells in the matrix are used to describe the data's use by the agency at each node point. Data generation and storage is shown in bold type, data usage is in normal type. **Note that the only uses listed are those relating to flood warning and emergency management.** We certainly expect that this data will have much wider application, but have not attempted to list all of those alternative uses in this tool.

The first two network nodes in the matrix are an Archival Node and an Operations Node. These correspond to the two "central sites" described in the final report. While it is expected that either of these sites could run the system in the event of the loss of the other, one site should concentrate on real time access of operational data while the other concentrates on archiving data for use in risk analysis and flood plain studies.

Finally, there will be a number of nodes in the system for counties and municipalities. These have been grouped into three rows of the matrix:

- Large counties, like Maricopa and Pima, will have different needs and capabilities than will the other counties in the system.

- Small counties are characterized as not having full time staff dedicated to flood warning.

- Municipalities have emergency response requirements but probably do not have full time flood planning and warning staffs.

This organization is a refinement of our original Tier 1 and Tier 2 division of network users.

DATA AND PRODUCT MATRIX

	SATELLITE OBSERVATIONS	NWS NATIONAL PRODUCTS	NEXRAD
Archival Node	**Stores** sequences from selected events	**Stores** products for selected events	**Stores** sequences from selected events
Operations Node	**Stores** last **N** frames	**Stores** all products for ongoing event	**Stores** last **N** frames
Commercial Services	Provides for subscribers Uses to generate products	Provides for subscribers Uses to generate products	Provides for subscribers Uses to generate products
ADWR	Reads prior to and during emergencies	Reads prior to and during emergenices Assists NWS in emergencies	Reads during emergency operations
ADEM		Reads during emergency operations	Reads during emergency operations
CAWCD		Reads during emergency operations	Reads during emergency operations
Climatologist	**Stores** sequences from selected events		**Stores** sequences from selected events
COE	Reads during emergency operations	Reads during emergency operations	Reads during emergency operations
Large Counties	Reads prior to and during emergency operations	Reads prior to and during emergency operations	Reads during emergency operations
Small Counties		Reads during emergency operations	
Municipalities		Reads during emergency operations	
NWS	Uses to generate forecasts	**Generates**	**Generates**
SRP	Uses to generate forecasts Reads during emergency operations	Reads during emergency operations	Uses to generate forecasts Reads during emergency operations
USBR	Reads during emergency operations	Reads during emergency operations	Reads during emergency operations
USGS			

DATA AND PRODUCT MATRIX

	SURFACE OBSERVATIONS	NWS LOCAL PRODUCTS
Archival Node	**Stores**	**Stores** for selected events
Operations Node	**Stores** last **N** observations	**Stores** all products for ongoing event
Commercial Services	Provides for subscribers Uses to generate products	Reads during emergency operations Uses to generate products
ADWR	Reads prior to and during emergenices Provides some to NWS	Reads during emergency operations Assists NWS and ADEM
ADEM	Reads during emergency operations	Reads during emergency operations
CAWCD	Reads	Reads
Climatologist	**Stores**	
COE	Reads during emergency operations	Reads during emergency operations
Large Counties	Reads prior to and during emergency operations	Reads prior to and during emergency operations Receives via alternative means
Small Counties		Reads during emergency operations Receives via alternative means
Municipalities		Reads during emergency operations Receives via alternative means
NWS	Uses to generate products	**Generates**
SRP	Uses to generate forecasts Reads	Reads
USBR	Reads during emergency operations	Reads during emergency operations
USGS		

DATA AND PRODUCT MATRIX

	BASIN LEVEL QPF	STORM TRACK MAP	SNOTEL GAUGES
Archival Node	**Stores**	**Stores**	**Stores**
Operations Node	**Stores** for ongoing event	**Stores** for ongoing event	**Stores** last **N** observations
Commercial Services	**Generates**	**Generates**	Uses for QPF verification Uses for watershed modeling
ADWR	Reads during emergencies	Reads during emergencies	Uses for water supply forecasts
ADEM	Reads during emergency operations	Reads during emergency operations	Reads during emergency operations
CAWCD	Reads during emergency operations	Reads during emergency operations	Uses for water supply forecasts
Climatologist			**Stores**
COE	Reads during emergency operations	Reads during emergency operations	Uses for water supply forecasts Reads during emergency operations
Large Counties	Reads prior to and during emergency operations Uses for modeling	Reads during emergency operations Uses to generate warnings	
Small Counties			
Municipalities			
NWS	**Generates**	**Generates**	Uses to generate products
SRP	**Generates**	**Generates**	**Generates** Uses to generate stream flow forecasts Uses for water supply forecasts Reads during emergency operations
USBR	Reads during emergency operations	Reads during emergency operations	Uses for water supply forecasts
USGS			**Generates** **Stores** **(Also SCS)**

DATA AND PRODUCT MATRIX

	RESERVOIR TELEMETRY	SOIL MOISTURE	WATERSHED MODEL RUNS
Archival Node	**Stores**	**Stores**	**Stores** for selected events
Operations Node	**Stores** last **N** observations	**Stores** last **N** observations	**Stores** latest relevant runs
Commercial Services		Uses for basin model runs	**Generates**
ADWR	Uses for safety of dams	Uses for basin model runs	**Generates** Uses for safety of dams/flood warning
ADEM	Reads during emergency operations		Reads during emergency operations
CAWCD			**Generates** for own watersheds (by CBRFC)
Climatologist			
COE	**Generates** for own reservoirs Reads during emergency operations	**Generates** for own watersheds	**Generates** for own watersheds
Large Counties	Reads during emergency operations	Uses for basin model runs	**Generates** for own watersheds
Small Counties			
Municipalities			
NWS		Uses for basin model runs	**Generates** (NWSFO and CBRFC)
SRP	**Generates** for own reservoirs Reads during emergency operations	**Generates** for own watersheds	**Generates** for own watersheds
USBR	**Generates** for own reservoirs Reads during emergency operations	**Generates** for own watersheds	**Generates** for own watersheds
USGS			

DATA AND PRODUCT MATRIX

	RESERVOIR RELEASE SCHEDULES	PREDICTIVE HYDROGRAPHS	LIGHTNING DATA	RAIN GAUGE DATA
Archival Node	**Stores** for selected events	**Stores** for selected events	**Stores**	**Stores** the data (After QC)
Operations Node	**Stores** latest	**Stores** latest	**Stores** last **N** observations	**Stores** the data (Before QC), Provides real time acce
Commercial Services		**Generates**	Provides for subscribers Uses to generate products	**Generates** synthetic data Uses to generate products
ADWR	Reads during emergencies	**Generates**		Flood plain studies, Safety of dams
ADEM	Reads during emergency operations	Reads during emergency operations	Reads during emergency operations	Reads during emergency operations
CAWCD	**Generates**	**Generates** (by CBRFC)	Reads	Uses for demand projection
Climatologist			**Stores**	**Stores** (After QC), Performs QC
COE	**Generates**	**Generates**	Reads during emergency operations	Flood plain studies, Safety of dams
Large Counties	Reads during emergency operations	**Generates**	Reads during emergency operations	**Generates**, Uses for emergency operations, Uses for warning plans, Uses for watershed modeling
Small Counties				**Generates**, Uses for emergency operations, Uses for warning plans
Municipalities				
NWS	Reads during emergency operations	**Generates** (PHX NWSFO, CBRFC) Reads during emergency operations	Uses to generate products	Uses to generate products
SRP	**Generates**	**Generates**	Uses to generate forecasts	**Generates**, Emergency operations, Reservoir operations, Watershed modeling, Water supply studi
USBR	**Generates**	**Generates**	Reads during emergency operations	**Generates**, Emergency operations, Reservoir operations, Watershed modeling, Water supply studi
USGS				**Generates, Stores Performs QC** Provides real time access,

DATA AND PRODUCT MATRIX

	STREAM FLOW (STAGE) DATA	ALARM MESSAGES (INTERNAL)	PUBLIC WARNINGS
Archival Node	**Stores** the data (After QC)	**Stores**	**Stores**
Operations Node	**Stores** the data (Before QC), Real time access	**Stores** last **N** messages	**Stores** last **N** messages
Commercial Services	Uses for watershed modeling	**Generates**	
ADWR	Uses for safety of dams, Uses for watershed modeling	Uses to assist local entities in emergencies	Assists NWS in generating
ADEM	Reads during emergency operations	Reads during emergency operations	Reads during emergency operations
CAWCD	Reads during emergency operations Reads for daily reservoir operatons		
Climatologist	**Stores**		
COE	**Generates,** Uses observations from upstream		
Large Counties	**Generates** Uses during emergency operations	**Generates** Uses during emergency operations	**Generates**
Small Counties	**Generates** Uses during emergency operations	**Generates** Uses during emergency operations	**Generates**
Municipalities		Uses to generate public messages	**Generates**
NWS	Uses for watershed modeling	Uses to generate warnings	**Generates**
SRP	**Generates**	**Generates**	**Generates**
USBR		**Generates**	**Generates**
USGS	**Generates** **Stores** **Performs QC** Provides real time access		

APPENDIX F

CONCEPT DESIGN DIAGRAMS

FUNCTIONAL AND INFORMATION FLOW DIAGRAM (Figure F-1)

This diagram describes the functions of the players within a statewide network. In many cases, a single agency occupies a single box on the diagram. However, there are cases where the functions of a single agency are split between two boxes. In that case, there is a dotted box drawn around the two boxes. This indicates that it is possible, for example, to have an agency which only performs the emergency management function as well as an agency which does that plus policy and logistics. The links between the boxes are labeled with the information that needs to be exchanged when managing a flood.

The only box on the diagram that may not be familiar is that for a local hydrometeorological service. This function develops tailored products at a higher resolution than is currently provided by the National Weather Service. This function is currently performed by the Salt River Project for internal purposes only. There is a common desire among interviewees to have such products become available on a much wider basis. Hence, the clouded box wherein tailored hydromet products flow from a local service to the emergency management agencies. In this instance, there is no implication that the service would or should be provided by SRP although that might be the case.

The following paragraphs describe the characteristics of the functions and agencies within the various boxes in the diagram.

- **National Weather Service Field Offices**
  - The NWS provides weather forecasts, QPF's, flash flood and flood watches/warnings.
  - They have access to large quantities of high quality, real time data
  - They have people trained in the rapid assimilation of diverse data for purposes of making forecasts.
  - They have real time communication capabilities with such agencies as the USGS, CBRFC, NOAA, SRP, etc.
  - Their communication with the public and with emergency management agencies tends to be of lower bandwidth than their communications with peer agencies. Warnings and forecasts to the public tend to be textual with limited graphics and little feedback.
- **Colorado Basin River Forecast Center**
  - CBRFC provides streamflow forecasts using real-time data and Quantitative Precipitation Forecasts (QPF's) for basins in Arizona.
  - They have access to large streams of high quality, real time data.
  - They have real time communication with peer agencies, nation wide.
  - They have trained people who are able to use sophisticated models and data from various sources to develop and disseminate their products rapidly.
  - They have little direct contact with emergency management agencies, and there is little feedback from such agencies.

- **Large Agency with Operating Responsibility**
  - These agencies have responsibility for operating large impoundments on major rivers.

  - Because of the large volumes of water these agencies manage and because of the public safety and economic consequences of their actions, these agencies must look deep, both in time and space, and plan their operations months in the future.

  - They have access to large quantities of real time data, often getting that data directly from the sources via satellite.

  - They have permanent staffs whose job it is to manage that data and draw the proper operating conclusions.

  - They often maintain high bandwidth, peer to peer communications with other large agencies and with national agencies such as the NWS and the CBRFC.

  - They generally have significant computing power and the ability to run various models of their systems to help them in decision making.

  - Examples of such agencies would be the Corps of Engineers, the US Bureau of Reclamation and the Salt River Project.

- **Local Meteorological Service**
  - Provides "value added" basin-/site-specific QPF, storm track and runoff forecasts to emergency management agencies and large agencies with operating responsibility.

  - Has access to high quality data streams, real time. These data often are obtained from sources via satellite.

    - Satellite imagery
    - Doppler radar data
    - Gauge data
    - Lightning data
    - Surface observations
    - Antecedent soil moisture

  - Has people who are trained to digest the above data quickly and make forecasts specific to local watersheds.

  - Communicates real time with the NWS, CBRFC and large water management agencies in forming professional judgments.

  - Can provide local emergency management agencies with information as to what the NWS forecast may mean in their specific situation.

- **Policy and Logistical Agencies**
  - These agencies provide logistical support to emergency management agencies.
  - They aid local agencies in developing flood warning policy. They work with state and federal agencies to obtain necessary legislation and funding.
  - They have full time people who work with ALERT systems on a daily basis.
  - They may procure, install and maintain hardware (computers, gauges, weather stations, etc.) and software.
  - They may provide basin modeling expertise for purposes of system calibration.
  - They may help develop emergency response plans for local emergency management agencies.
  - They may design and implement special output products for specific agencies and basins.
  - They perform data archiving and quality control.
  - They may provide some direct warning services to small entities on a prearranged basis, but the bulk of their work tends to come before and after flood event. During events, their people may relocate to provide basin expertise to some other organization, (e.g. ADWR staff provides support to the NWS).
- **Emergency Management Agencies**
  - Emergency management agencies are responsible for implementing flood response plans in order to preserve life and property. They are responsible for developing such plans and exercising them as needed.
  - They are responsible for monitoring the ALERT system in their basin.
  - They tend not to have full time staff that is dedicated to flood control. Because of this, they need information rather than data. That is, they need products which are tailored to their situation and which tell them quickly what the current situation is.
  - They tend not to have full time staff that can configure the software on a base station and trouble shoot the system.
  - They tend not to have staff hydrologists who can perform basin modeling and so predict the response time of their basin(s) of concern.

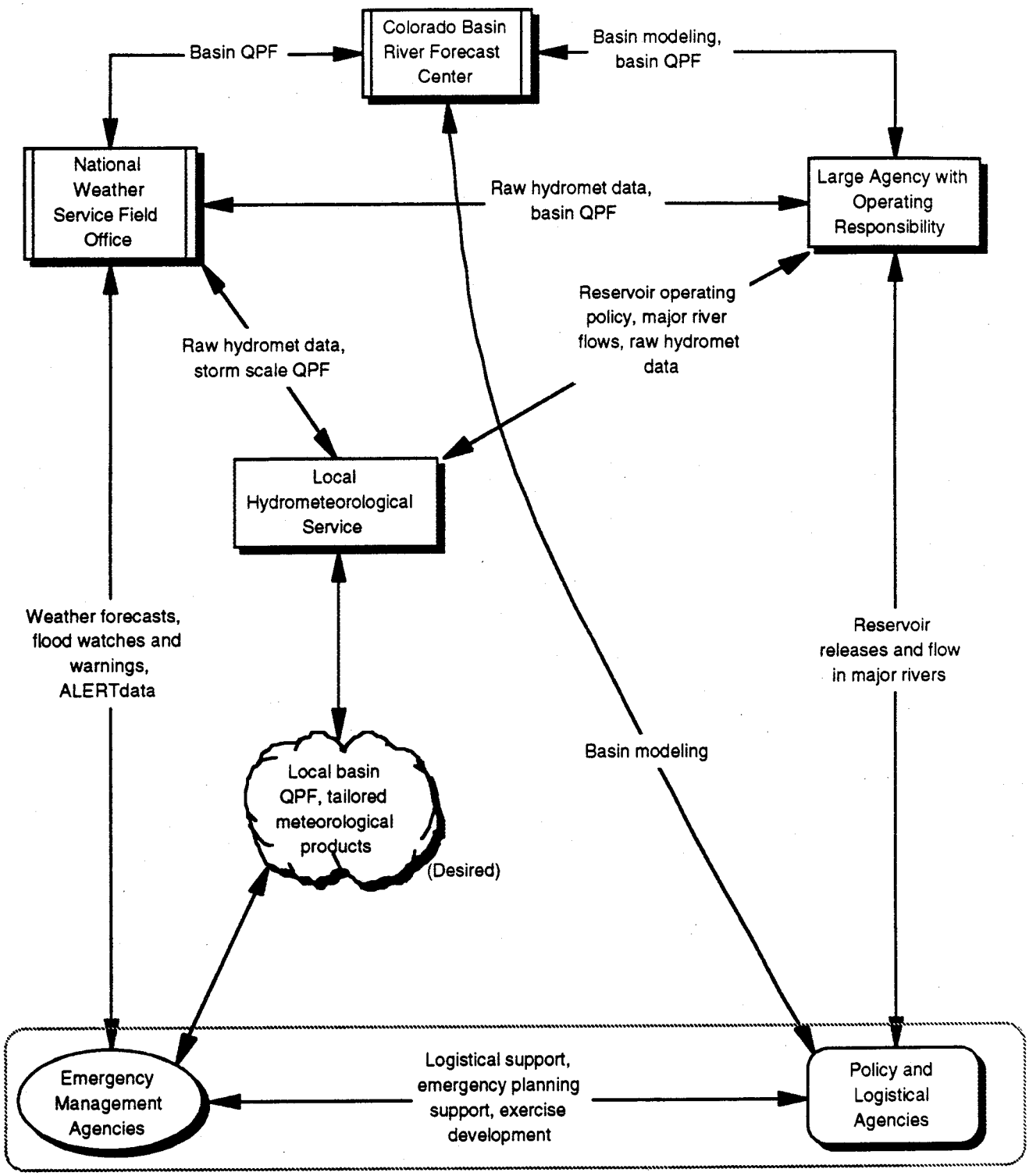

FIGURE F-1

Functional and Information Flow Diagram

CONNECTIVITY AND DATA FLOW DIAGRAMS

These two diagrams are a refinement and extension of the Functional and Information Flow Diagram. The functions in the prior diagram have been solidified into agency types and data sources and repositories have been added.

In the first of these two diagrams (Figure F- 2), we show input data as divided between high level sources and local basin instrumentation. The high level sources are maintained and distributed by the NWS, other national agencies or large commercial services. The local basin instrumentation is owned by either the emergency response units or by the nearest logistical agency.

Data storage has been divided functionally into an operational database and an archival database. The former contains raw observations that are intended immediately to be available to all points within the network. The latter contains data that has been quality checked and is intended to be used for analysis and research. In addition to observations, both databases will contain bulletin board type products such as NWS warnings, reservoir operating schedules, etc.

In the second of the two Connectivity and Data Flow Diagrams (Figure F-3), the external data sources have been aggregated into a single box and the two functional databases have been collapsed into a single hydromet database. This is for diagrammatic clarity only, the functions are as in the first diagram.

In the second diagram, we have labeled the links among the various boxes with representative communication types. These are notional and are designed to represent the capacity of the communication link rather than the actual appliances that might be used. Thus, a voice phone line or a dial in modem are equivalent, being able to carry a single voice conversation or something less than 30 KBPS (thousand bits per second) of data. (This figure can go up or down slightly depending on data compression and the degree of error tolerance, but is a good benchmark.) The point here is that the grade of the communication link limits the amount of data and the types of display that are available at any node in the system. A node that is connected by a voice grade line will not be able to receive real time radar or satellite animation products. Rather, it will rely most heavily on text products and graphical products that are generated locally.

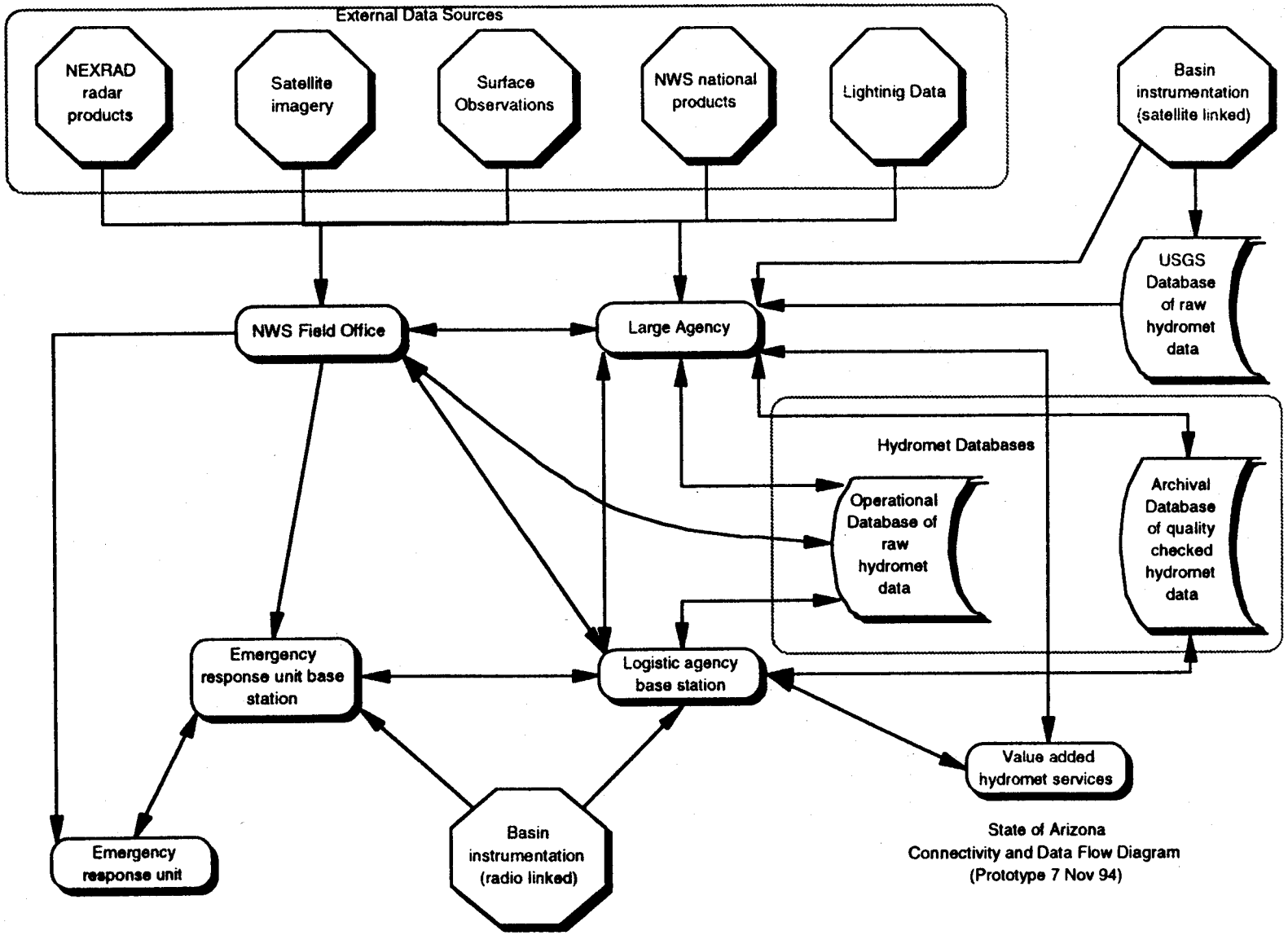

FIGURE F-2

Connectivity and Data Flow Diagram I

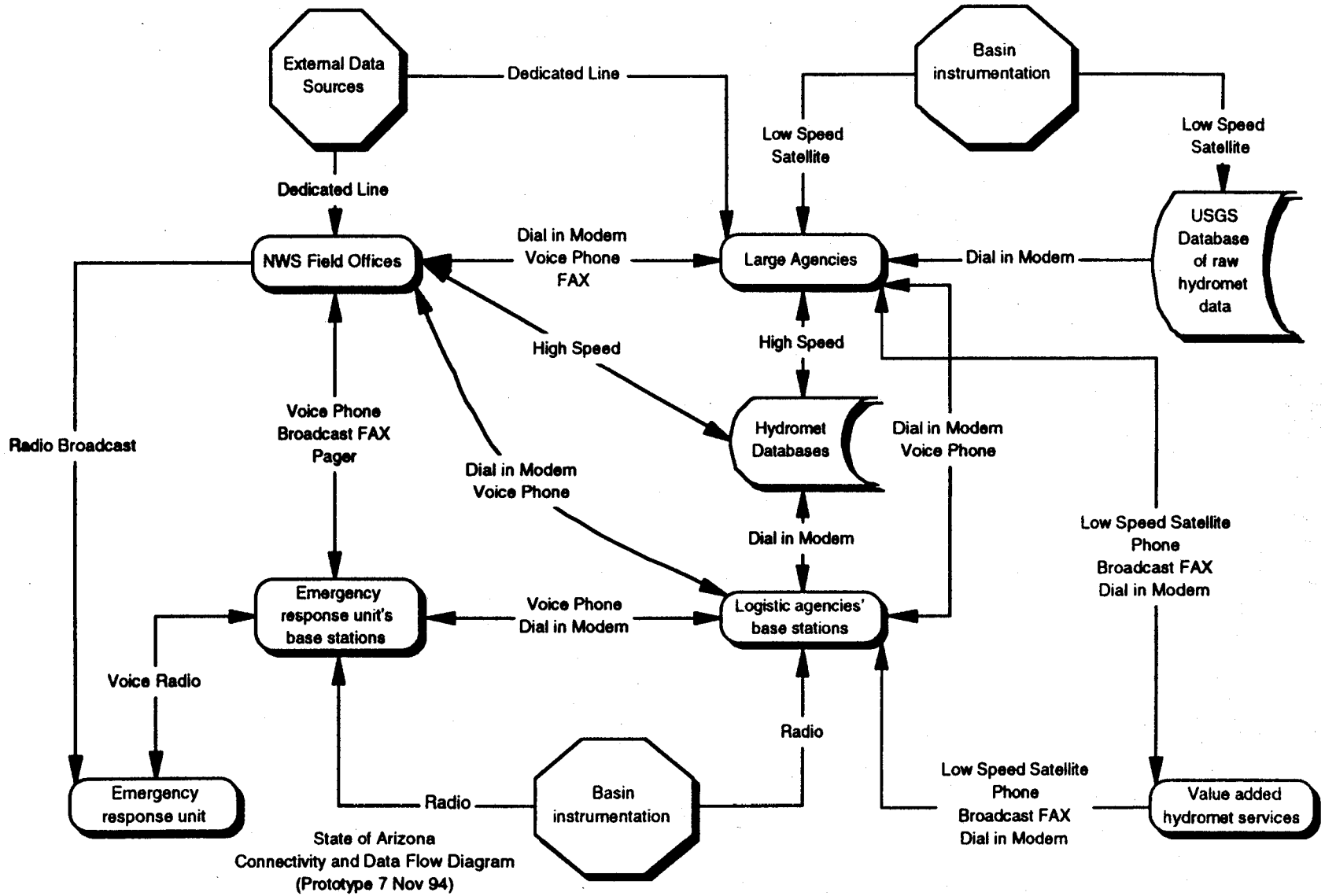

FIGURE F-3

Connectivity and Data Flow Diagram II