Technical Memorandum No. 4.4.2

Task:	**4.4.2 Evaluate Automated Local Evaluation in Real Time (ALERT) Gages**
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Introduction

This technical memorandum (TM) describes work completed as part of *Task 4.4.2: Evaluate Automated Local Evaluation in Real Time (ALERT) Gages* as part of the Pajaro River Watershed Study. This subtask is part of a greater effort in the preparation of a flood forecasting system for the Pajaro River watershed upstream of Chittenden Pass. In this effort, RMC was tasked with identifying the existing ALERT stations (stream, reservoir, and precipitation stations) within the Pajaro River watershed. Additionally, RMC documented the operating accuracy of the existing systems in the basin, and identified and evaluated the need for additional ALERT sites to enhance the flood forecasting coverage and information available to interested agencies.

Data Acquisition Methodology

To obtain the information presented in this TM, the following agencies that support or operate hydrometeorologic monitoring systems within the Pajaro Watershed were consulted:

1) U. S. Geological Survey (USGS), Water Resources Division Field Office, Marina, CA
2) National Weather Service (NWS), Weather Forecasting Office (WFO), Monterey, CA
3) NWS California-Nevada River Forecasting Center (CNRFC), Sacramento, CA
4) California Irrigation Management Information System (CIMIS), Sacramento, CA
5) Santa Clara Valley Water District (SCVWD), San Jose, CA
6) San Benito County Water District (SBCWD), Hollister, CA
7) Santa Cruz County Flood Control and Water Conservation District, Zone 7, Santa Cruz, CA
8) Monterey County Water Resources Agency (MCWRA), Salinas, CA

Data acquisition for this TM began in the height of the 2004/2005 flow season, which posed time constraints on resource agencies to provide information for this TM. Through a series of telephone calls, email transmissions, and faxes, as well as web searches, the following ALERT information was collected. No field investigations were performed for this TM. It is important to note that this TM is not all-encompassing of ALERT information regarding the Pajaro River watershed and if subsequent implementation of a flood forecasting system is to occur, further technical and feasibility evaluation is needed.

ALERT Background

ALERT is the acronym for Automated Local Evaluation in Real Time[1]. An ALERT Flood Warning System, as defined by the National Weather Service, is a cooperative, community-operated flood warning system[2]. This system is comprised of monitoring stations that provide automated evaluation of hydrologic and meteorologic data in real time. The real-time, or instantaneous, transmission and dissemination of

[1] Abelman, C. December 2004. Glossary of Hydrologic Terms –A. National Weather Service, http://www.srh.noaa.gov/wgrfc/resources/glossary/a.html.
[2] Abelman, 2004

hydrometeorological data for weather events is crucial to local communities at risk of flooding.

ALERT was developed in the 1970's by the California-Nevada River Forecast Center (CNRFC), a field office of the National Weather Service (NWS, an agency of the National Oceanic and Atmospheric Administration)[3,4]. ALERT systems aid local agencies, such as city and county flood and water resources districts, in providing local flood warning by generating real-time, automated hydrometeorological sensor information.

In an ALERT system, monitoring stations are equipped with event-reporting field sensors that immediately retrieve, transmit, and notify its users of hydrometeorological events, such as when rainfall occurs and when stream flow or reservoir storage fluctuates[5]. The resulting data may illustrate precipitation accumulation, river flow, and river or reservoir stage. It is important to note that all ALERT data are provisional due to their real-time nature. The data retrieved through an ALERT system have not received typical quality assurance and quality control. Therefore, it is up to the user to exercise discretion when interpreting ALERT data.

The instantaneous transmission of ALERT weather and flow data occurs primarily through very high frequency (VHF) radio telemetry. Other, less utilized, transmission types are telephone land lines, cellular telephone, and satellite. The basic components of a VHF radio-equipped ALERT system are illustrated in **Figure 1**[6].

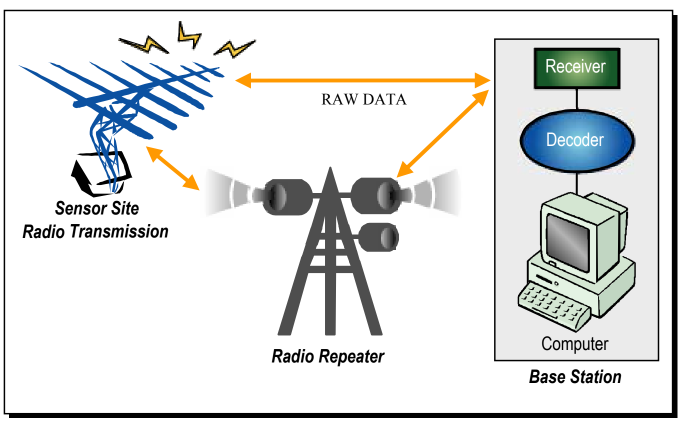


Figure 1: Radio Telemetry ALERT System

VHF Radio ALERT systems rely on line-of-sight radio communications between the sensor site and a base station. When direct line-of-sight telemetry is not possible between

[3] National Weather Service. December 2004. Service Hydrologist Program. http://www.nws.noaa.gov/om/hod/SHManual/SHMan001_alert.
[4] Daves, D. Santa Clara Valley Water District. Personal communication via email. January 5, 2005.
[5] Santa Clara Valley Water District. December 2004/January 2005. Online ALERT database. http://www.valleywater.org/Water/Technical_Information/Measures_and_Readings/ALERT_data_system.shtm
[6] National Weather Service. February 1997. Automated Local Flood Warning Systems Handbook. www.nws.noaa.gov/oh/docs/alfws-handbook/ (Concept for graphic originates from this publication).

the sensor site and the base station, one or more radio repeaters, or relay stations, are utilized to transmit the coded signals[7]. Each ALERT base station has a radio receiver to pick up the signal and a decoder to translate the data[8]. Once the data are decoded, the ALERT base station software applies calibrations to the data so they are meaningful to the user[9].

Utilizing ALERT software at the base station, the data can be logged into a computer database for analysis, subsequent review, report generation, and archiving[10]. ALERT systems can also be pre-programmed to notify key operations, maintenance, and emergency personnel when certain monitoring thresholds have been exceeded[11]. Such alarms may allow timely action in the prevention of floods.

All local agencies tasked with ALERT utilize the same federally owned and licensed VHF radio frequencies[12]. The NWS California-Nevada River Forecast Center (CNRFC) provides frequency licensing to western ALERT users in a cooperative effort to provide local flood warning information[13]. In order to prevent duplicate sensor transmissions, the CNRFC coordinates the frequency of, and assigns individual station identification numbers to, each ALERT sensor[14].

The frequencies used to transmit and receive ALERT data are 169.00 through 174.000 megahertz (MHz)[15]. Since these frequencies are shared, transmissions of data can occur through shared repeater sites and participating agencies can retrieve ALERT information from sensors outside their jurisdictional area[16]. Data are available to both the ALERT users (operators) and other interested agencies such as the NWS[17], who receives all ALERT data transmissions[18].

ALERT systems require regular maintenance. Many sensor sites are powered by a rechargeable battery with solar power, or if available, alternating current (AC) power with a battery as a backup power source[19]. These power systems are monitored often and recharged, as needed[20]. Also, every sensor requires calibration appropriate to the sensor type. Additionally, base stations also require a type of calibration, or "base setting", for the data to be useful[21]. On-going maintenance and calibration must occur for any ALERT system. Most agencies perform quarterly to annual maintenance visits to each

[7] Daves, 2005
[8] Franklin, H. Monterey County Water Resources Agency. December 2004. Personal communication via email and telephone.
[9] Daves, 2005
[10] Santa Clara Valley Water District, 2004/2005
[11] National Weather Service, 1997, and Daves, 2005
[12] Daves, 2005
[13] Daves, 2005
[14] Daves, 2005
[15] Daves, 2005
[16] Daves, 2005
[17] Santa Clara Valley Water District, 2004/2005
[18] Daves, 2005
[19] Daves, 2005
[20] Ray, J. San Benito County Water District. January 2005. Personal communication via telephone.
[21] Daves, 2005, and Franklin, 2004

site. More frequent visits usually occur during the storm season in order to ensure the integrity of the system during this critical time[22].

Alert System Operation

At the first sign of an approaching weather system that may bring heavy rains or a prolonged rainfall, if the hydrology program manager believes a flooding threat may be imminent, the manager mobilizes a trained ALERT team of personnel. The personnel observe the ALERT hydrometeorologic sensors (through computer access) for the duration of the storm(s) and a period of time after the storm to account for subsequent flows. Personnel monitor the peak flows as the flood waves move through the system. Since severe rainfall is the first sign of a possible flood, the precipitation sensors are the first ALERT sites to be monitored. As the storm progresses, ALERT personnel watch the precipitation sites for changes in storm intensity and location, and monitor river stage sensors for the watershed's response to storm runoff.

The amount of runoff will depend on antecedent soil moisture conditions, vegetative cover, and many other environmental and anthropomorphic factors in a watershed. As a result of these factors, a lag time exists between the rainfall event and the occurrence of runoff in the local drainage. The response of a watershed to a rainfall event (runoff) is illustrated in a storm hydrograph, which can be created by ALERT personnel or may be automatically generated by ALERT computer system software utilizing the ALERT stage sensor data. Peak flows observed in upper watersheds can be tracked as they move through the system and merge downstream. Peak flow data can also be used to develop time-of-travel information for a given storm.

ALERT users are usually equipped with stage monitoring guidelines developed for key river monitoring sites in the watershed (such as upstream of a city or facility). These guidelines establish water level thresholds that indicate to the ALERT user advanced levels of flooding in a system. Examples of thresholds are "monitor stage", "flood stage", and "danger stage"[23]. All stages indicate a higher level of threat to life and property than normal, and the specifics of each stage vary depending on channel configuration and floodplain development.

Armed with ALERT data, an ALERT user can provide vital information and early warning to local communities. This information can be used to mobilize for flood events or to regulate facilities downstream.

Pajaro River Watershed ALERT

The Pajaro River watershed lies within the jurisdictional boundaries of the counties of San Benito, Santa Clara, Santa Cruz, and Monterey. This watershed is monitored by ALERT stations and gages strategically located throughout the drainage. Each county owns, operates, maintains, and monitors a network of ALERT sites. The following are the agencies with this responsibility: San Benito County Water District, Santa Clara

[22] Daves, 2005, and Franklin, 2004
[23] California Data Exchange Center. December 2004/January 2005. River Stage Definitions. http://cdec.water.ca.gov/stageInfo.html

Valley Water District, Santa Cruz County Flood Control and Water Conservation District, and Monterey County Water Resources Agency.

Existing ALERT Coverage

The existing ALERT coverage of the Pajaro River watershed consists of 25 sites (**Figure 2**). **Table 1** lists all ALERT stations located on Figure 2 and provides additional information about each.

Of the 25 ALERT sites mapped in Figure 1, 23 sites are located within the boundaries of the Pajaro River watershed. Two precipitation sites, Gloria Grade and Fremont Peak, are located in the Salinas River watershed just beyond the Pajaro River watershed divide to the west. Since they are located close to the watershed divide, these sites may provide valuable rainfall data where data aren't otherwise available. In conjunction with McPhails Peak, Fremont Peak and Gloria Grade comprise the ALERT precipitation coverage along the upper Gabilan Range in the Pajaro River watershed.

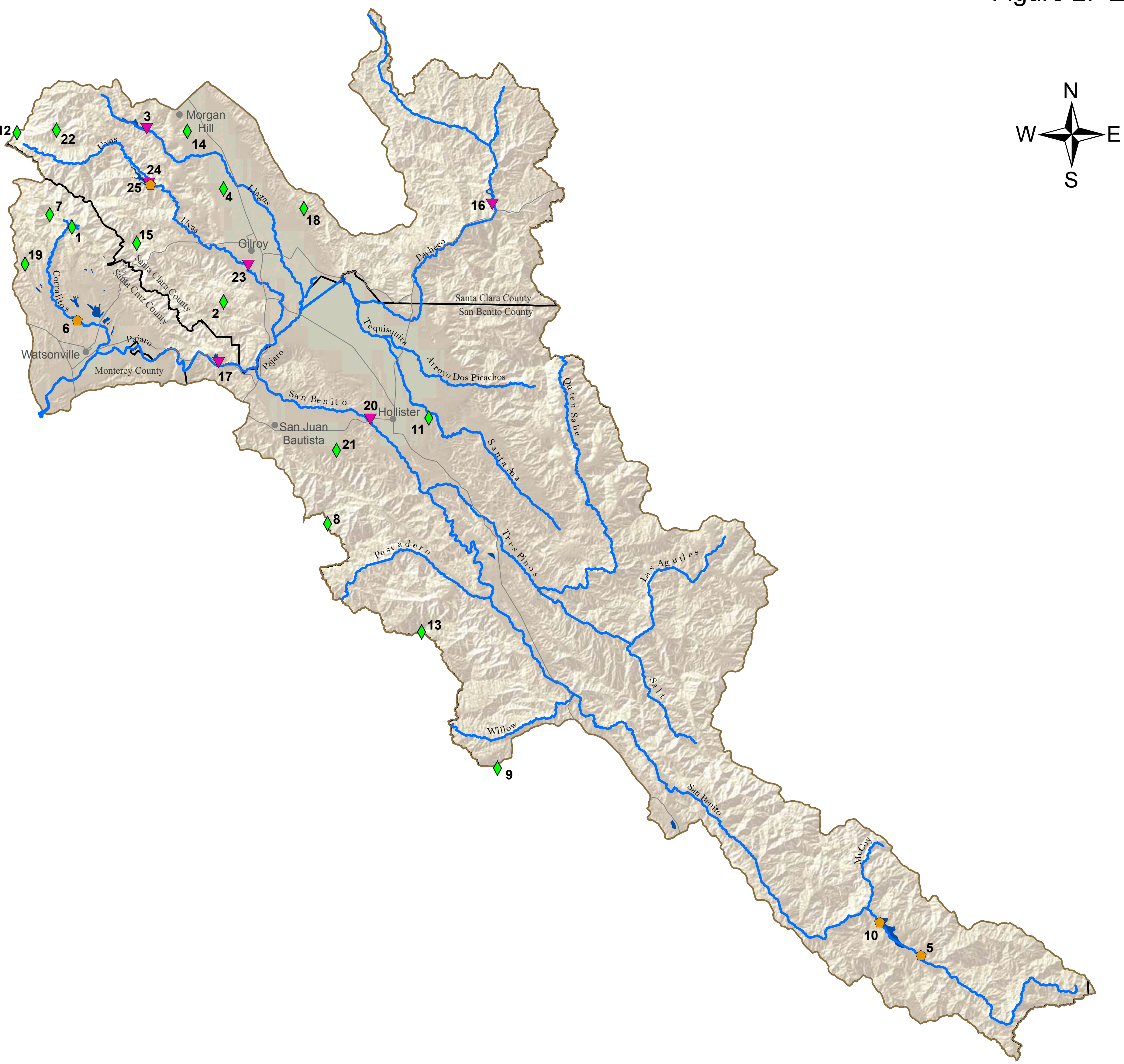
Overall, 15 ALERT sites monitor precipitation only, 6 ALERT sites monitor stage only, and 4 ALERT sites monitor both precipitation and stage. Reservoir stage is monitored at each of the four reservoirs - Pacheco, Uvas, Chesbro, and Hernandez.

Systems Accuracy

All agencies that operate ALERT equipment within the Pajaro watershed noted that, overall, their systems are working properly. However, from time to time stations may go down or inconsistencies are seen in the data. Such problems in an ALERT system can occur for any number of reasons. Some of these reasons include site vandalism, debris and/or insects inhibiting sensor function, vegetation encroachment to site, recalibration needed, radio interference, and power failure[24]. For these reasons, maintenance is a critical piece in a properly functioning ALERT system to produce accurate and reliable data. All agencies reported quarterly to annual maintenance visits to each Pajaro River Watershed ALERT site. More frequent visits usually occur during the storm season in order to ensure the integrity of the system during this critical time[25].

[24] Daves, 2005
[25] Franklin, 2004; Daves, 2005

Figure 2. Existing ALERT Sites of the Pajaro River Watershed



1 Browns Valley
2 Castro Valley RF 15
3 Chesbo Reservoir
4 Church Ave Perc Ponds RF 134
5 Clear Creek Crossing
6 Corralitos Creek at Freedom
7 Eureka Canyon
8 Fremont Peak
9 Gloria Grade
10 Hernandez Reservoir
11 Hollister
12 Loma Prieta RF 44
13 McPhails Peak
14 Morgan Hill RF 136
15 Mount Madonna
16 Pacheco Reservoir
17 Pajaro River at Chittenden
18 Peabody RF 75
19 Pleasant Valley
20 San Benito River at HWY 156 near Hollister
21 San Juan Oaks Golf Coarse
22 Uvas Canyon Park RF 135
23 Uvas Creek at W Luchessa Ave SF 86
24 Uvas Creek below Uvas Reservoir
25 Uvas Reservoir/ Uvas Reservoir RF 104

Legend

ALERT SENSOR TYPE

- Precipitation
- Stage
- Stage & Precipitation

OTHER FEATURES

- Cities
- Major Roads
- Rivers
- County Boundary

0 2.5 5 10 15 20 25 Miles

Table 1. Existing ALERT sites within the Pajaro River watershed[26]

No	Name	ALERT ID[27]	ALERT Transmission Frequency[28]	CDEC ID[29]	USGS ID[30]	County	Operating Agency of ALERT Sensor	Sensor Type	Elevation (Feet above sea level)	North Latitude[31] (Decimal Degrees)	West Longitude[32] (Decimal Degrees)	Notes/Comments
1	Browns Valley	1995	166.075			Santa Cruz	SCCDPW	Precipitation	630	37.02472	121.77722	
2	Castro Valley RF 15	1508	166.075			Santa Clara	SCVWD	Precipitation	754	36.95833	121.60056	
3	Chesbo Reservoir	1470	170.225	CHR		Santa Clara	SCVWD	Stage (Reservoir)	540	37.11667	121.69278	This sensor measures reservoir storage.
4	Church Ave Perc Ponds RF 134	1529	170.225			Santa Clara	SCVWD	Precipitation	260	37.06250	121.60278	
5	Clear Creek Crossing	1435/1432				San Benito	SBCWD	Stage/Precipitation	2,438	36.36389	120.78889	Full weather station at inlet to reservoir.
6	Corralitos Creek at Freedom	1990/1991	166.075		11159200	Santa Cruz	SCCDPW	Stage/Precipitation	100	36.93917	121.76917	
7	Eureka Canyon	1997	166.075	EKN		Santa Cruz	SCCDPW	Precipitation	1,660	37.03583	121.80306	
8	Fremont Peak	1059	166.075			Monterey	MCWRA	Precipitation	2,880	36.76997	121.49420	Located just outside watershed.
9	Gloria Grade	1063	166.075	GGR		Monterey	MCWRA	Precipitation	1,960	36.5320	121.2770	Located just outside watershed.
10	Hernandez Reservoir	1232/1231/1226	170.225			San Benito	SBCWD	Stage (Reservoir)/ Stage (Reservoir Outlet)/ Precipitation	2,413	36.39417	120.83667	A temperature sensor, with ALERT ID 1228, also exists at this site.
11	Hollister	1233	170.225	HLS		San Benito	SBCWD	Precipitation	340	36.85417	121.36167	CIMIS[33] weather station
12	Loma Prieta RF 44	2072	171.100			Santa Clara	SCVWD	Precipitation	3,778	37.11083	121.84278	
13	McPhails Peak	1442		PHA		San Benito	SBCWD	Precipitation	3,553	36.65670	121.36640	
14	Morgan Hill RF 136	1503	170.225			Santa Clara	SCVWD	Precipitation	53	37.11500	121.64583	
15	Mount Madonna	1085	166.075	MMD		Santa Clara	MCWRA	Precipitation	1,882	37.01100	121.70200	
16	Pacheco Reservoir	1474	171.100			Santa Clara	SCVWD	Stage (Reservoir)	485	37.05197	121.29173	This station measures reservoir storage.
17	Pajaro River at Chittenden	1252	166.075	CHT	11159000	Santa Cruz	MCWRA	Stage	140	36.90200	121.60500	
18	Peabody RF 75	1523	170.225			Santa Clara	SCVWD	Precipitation	472	37.04556	121.50944	
19	Pleasant Valley	1993	166.075			Santa Cruz	SCCDPW	Precipitation	360	36.98972	121.83056	
20	San Benito River at HWY 156 near Hollister	1332	170.225	SBH	11158600	San Benito	MCWRA	Stage	242	36.85200	121.42900	
21	San Juan Oaks Golf Coarse	1238	170.225			San Benito	SBCWD	Precipitation	245	36.82306	121.46750	CIMIS weather station
22	Uvas Canyon Park RF 135	1530	170.225			Santa Clara	SCVWD	Precipitation	1,099	37.11389	121.79722	
23	Uvas Creek at W Luchessa Ave SF 86	2084	170.225			Santa Clara	SCVWD	Stage	220	36.99222	121.57250	
24	Uvas Creek below Uvas Reservoir	1538				Santa Clara	SCVWD	Stage		37.06611	121.68917	This station measures Uvas Reservoir outlet releases only - it does not measure spillway flows, which can be significant. Also, water may be transferred from Uvas Reservoir to Llagas Creek via the Uvas-Llagas Transfer Line.[34]
25	Uvas Reservoir/ Uvas Reservoir RF 104	1472/2078	170.225			Santa Clara	SCVWD	Stage (Reservoir)/ Precipitation	500/489	37.06556	121.68750	The stage sensor here measures reservoir storage.

[26] The data sources for this table include the following (if data are missing, the information was not readily found through these sources):
California Data Exchange Center. December 2004/January 2005. Various site home pages. http://cdec.water.ca.gov/;
California Irrigation Management Information Systems. December 2004/January 2005. Various weather site home pages. http://wwwcimis.water.ca.gov/cimis/info.jsp;
Franklin, 2004; Laclergue, B. Santa Cruz County Flood Control and Water Conservation District. December 2004. Personal communications via telephone and facsimile;
Ray, 2005; Santa Clara Valley Water District, 2004/2005; Stremel, J. Pacific Coast Forecasting. January 2005. Personal communication via telephone; Stumpf, K. Santa Clara Valley Water District. January 2005. Personal communication via email and telephone;
Terraserver-USA. January 2005. Sponsored by USGS and Microsoft Research. Various topographic maps and aerial photos. www.terraserver-usa.com; U.S. Geological Survey. December 2004/January 2005. Various gage site home pages. www.usgs.gov.

[27] Stumpf, 2005

[28] Stumpf, 2005

[29] The California Data Exchange Center (CDEC) has a cooperative database with extensive hydrologic data collected throughout the State. Information about some of the ALERT sites can be found in this database.

[30] ALERT sites that are also USGS gaging sites are noted.

[31] All coordinates in this table are approximate.

[32] All coordinates in this table are approximate.

[33] The California Irrigation Management Information System (CIMIS) manages a network of weather stations throughout the state.

[34] Santa Clara Valley Water District, 2004/2005

Expanded ALERT Coverage

In preparation for a flood forecasting system, the development of a more comprehensive monitoring network would provide supplemental real-time data in areas where data gaps exist, and would aid in the effort of enhanced flood forecasting. Utilizing Geographic Information Systems (GIS) capabilities and National Oceanic and Atmospheric Association (NOAA) Precipitation Frequency Atlas 2[35], several potential sites were identified in both the upper and lower Pajaro River watershed to expand the existing ALERT coverage. Also, some of these site recommendations originate from discussions with local agency ALERT program managers. Since these analyses did not include field visits to the recommended sites, further evaluation is required to determine site adequacy for flood forecasting.

When evaluating an ALERT monitoring network, precipitation is considered "the most influential parameter in the study of water balances and the calculations of water level and risk of flooding"[36]. With this in mind, precipitation is the primary consideration in determining the design of a monitoring network[37].

As stated in *ALERT Guidelines for the Collection of Hydrologic and Meteorologic Data* (1995), a precipitation gage density (areal distribution) of one ALERT gage for every 50 square kilometers (km^2) is reasonable for convective conditions[38]. Although local hydrologic and meteorologic conditions may differ, if this principal were applied to the Pajaro watershed (1,300 square miles in area, or 3,367 km^2), 67 precipitation gages would be needed[39].

However, in studies of annual precipitation versus gage density in Illinois, a precipitation network with one gage per 100 square miles produced less than five percent error in rainfall sampling[40]. This statistic would require 13 precipitation ALERT gages to be installed throughout the Pajaro River watershed; such a network would be smaller than what is in existence in the Pajaro watershed today.

Although the nature of precipitation events that produce threatening runoff vary from region to region, generally a higher density network of precipitation sensors will decrease errors in rainfall sampling[41] and will allow for greater understanding of a flooding threat. Also, a more enhanced network of sampling sites provides redundancy in precipitation sensor data, and helps to avoid a significant loss of data if one site were to fail[42].

[35] National Oceanic and Atmospheric Association. 1973. NOAA Atlas 2, Volume XI, Figure 43. Western Regional Climate Center. http://www.wrcc.dri.edu/pcpnfreq.html
[36] ALERT Users Group. July 1995. ALERT Guidelines for the Collection of Hydrologic and Meteorologic Data. Version 2.2. www.alertsystems.org
[37] ALERT Users Group, 1995
[38] ALERT Users Group, 1995
[39] ALERT Users Group, 1995
[40] ALERT Users Group, 1995
[41] ALERT Users Group, 1995
[42] ALERT Users Group, 1995

The approach taken for this network analysis was to establish ALERT precipitation stations at high rainfall points within the major subwatersheds of the greater Pajaro River watershed. Locating ALERT water level stations involved the identification of drainages whose flow is not captured in the current ALERT configuration. Since it may not be feasible to construct a new gage on every tributary, only those sites which may provide valuable flow data for flood forecasting purposes during high flow events are suggested.

Special attention was given to sites, such as those maintained by the USGS, where hydrometeorologic data sensors are currently in use but are not ALERT equipped. Installing ALERT equipment at such sites may be less costly than establishing a completely new monitoring station. Additionally, some sites that were previous monitoring points in the watershed are proposed. These sites may provide valuable historical data for that point in the watershed. It should be noted that all recommendations are preliminary and in-depth field investigations, radio path testing, cost comparisons, and feasibility analyses should be undertaken to accurately locate any new ALERT station.

Fifteen new site recommendations are proposed for enhanced ALERT coverage. The proposed ALERT sites are illustrated in **Figure 3**. All proposed ALERT sites are listed in **Table 2**.

Upper Pajaro River Watershed

Preliminary studies of the existing ALERT precipitation coverage in the upper watershed (upstream of Chittenden, including San Benito drainage) have revealed a great need for ALERT precipitation data. Currently, 10 ALERT sites are equipped with precipitation sensors in the upper watershed. Though there is no standard for optimum ALERT precipitation network density, many studies have shown that increased areal extent of data collection sites aids in decreased errors in data dissemination for flood forecasting.

To enhance the existing system of ALERT sites within the upper Pajaro watershed, twelve ALERT sites are proposed for the upper Pajaro River watershed. These sites include 6 precipitation and 6 stage sensor sites. The following paragraphs describe the reasons for proposing the ALERT sites.

Precipitation Site Recommendations

The existing precipitation stations of Idria and Santa Rita, operated by the California Department of Water Resources and California Department of Forestry, respectively, could be ALERT equipped to provide data in the Clear Creek and San Benito River subwatersheds above Hernandez Reservoir. Another existing precipitation station is located at Chittenden and is operated by the NWS. This site could also be equipped with ALERT capabilities. As stated previously, locating ALERT equipment at existing sites is usually less costly than establishing a completely new station. The three remaining sites, Henrietta Peak, Pacheco Reservoir, and Upper Tres Pinos, would need to be fully equipped with a precipitation station and ALERT equipment.

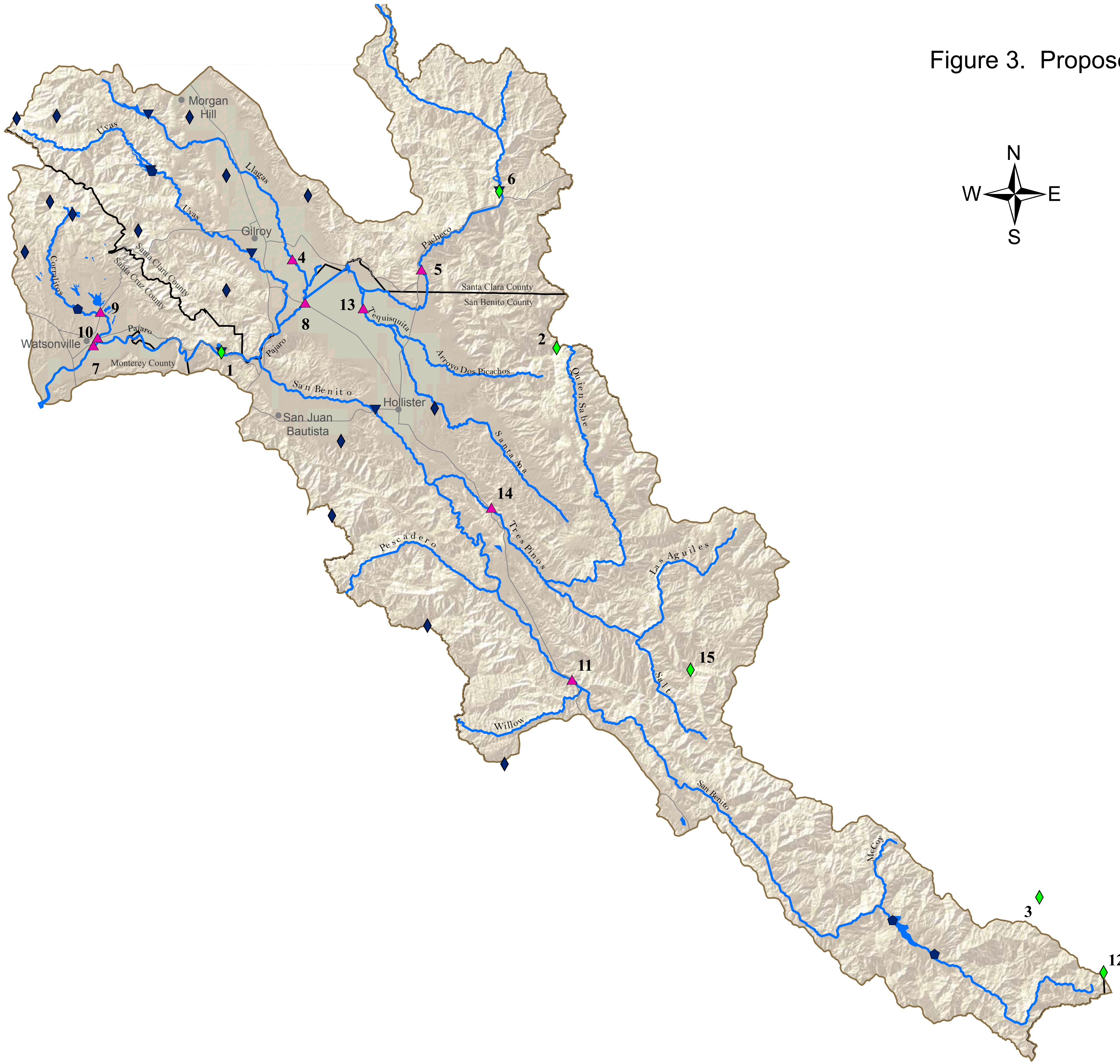


Figure 3. Proposed ALERT Sites of the Pajaro River Watershed

1 Chittenden
2 Henrietta Peak
3 Idria
4 Llagas Creek near Gilroy
5 Pacheco Creek near Dunneville
6 Pacheco Reservoir RF
7 Pajaro River at Watsonville
8 Pajaro River near Gilroy
9 Salsipuedes Creek at East Lake Ave.
10 Salsipuedes Creek below HWY 129
11 San Benito River near Willow Creek School
12 Santa Rita
13 Tequisquita Slough at Shore Rd.
14 Tres Pinos Creek near Tres Pinos
15 Upper Tres Pinos

Legend

PROPOSED ALERT SENSOR TYPE

- Precipitation
- Stage

EXISTING ALERT SITES

- Precipitation
- Stage
- Stage & Precipitation

OTHER FEATURES

- Cities
- Major Roads
- Rivers
- County Boundary

0 2.5 5 10 15 20 25 Miles

Table 2. Proposed ALERT sites for the Pajaro River watershed[43]

No	Name	CDEC ID	USGS ID	County	Sensor Type	North Latitude[44] (Decimal Degrees)	West Longitude[45] (Decimal Degrees)	Notes/Comments
1	Chittenden			Santa Cruz	Precipitation	36.90200	121.60500	NWS station exists here
2	Henrietta Peak			San Benito	Precipitation	36.91039	121.22420	No established precipitation site
3	Idria	IDR		Fresno	Precipitation	36.41600	120.67100	DWR site, satellite, tipping bucket
4	Llagas Creek near Gilroy		11153650	Santa Clara	Stage	36.98750	121.52611	USGS satellite transmitter installed at site[46]
5	Pacheco Creek near Dunneville		11153000	Santa Clara	Stage	36.98000	121.37917	Previous USGS site
6	Pacheco Reservoir RF			Santa Clara	Precipitation	37.05197	121.29173	No established precipitation site
7	Pajaro River at Watsonville		11159500	Santa Cruz	Stage	36.90625	121.75068	City of Watsonville River Monitor Site, Previous USGS site
8	Pajaro River near Gilroy		11153700	Santa Clara	Stage	36.94833	121.51083	Previous USGS site
9	Salsipuedes Creek at East Lake Ave.			Santa Cruz	Stage	36.93682	121.74344	City of Watsonville River Monitor Site, Previous USGS site
10	Salsipuedes Creek below HWY 129		365420121450001	Santa Cruz	Stage	36.91341	121.74607	City of Watsonville River Monitor Site, Previous USGS site
11	San Benito River near Willow Creek School		11156500	San Benito	Stage	36.60944	121.20194	Real-time USGS site
12	Santa Rita	SRI		San Benito	Precipitation	36.34800	120.59800	CA Dept. of Forestry site, satellite
13	Tequisquita Slough at Shore Road			San Benito	Stage	36.94410	121.44461	No established site
14	Tres Pinos Creek near Tres Pinos		11157500	San Benito	Stage	36.76472	121.29583	Real-time USGS site
15	Upper Tres Pinos			San Benito	Precipitation	36.61963	121.06778	No established site

[43] California Data Exchange Center. December 2004/January 2005;
California Irrigation Management Information Systems. December 2004/January 2005;
City of Watsonville Department of Public Works and Utilities. December 2004/January 2005. River Monitoring System. http://www.ci.watsonville.ca.us/river/;
Santa Clara Valley Water District, 2004/2005;
Terraserver-USA. January 2005;
U.S. Geological Survey. December 2004/January 2005.
[44] All coordinates in this table are approximate.
[45] All coordinates in this table are approximate.
[46] Stumpf, 2005

Stage Site Recommendations

The six proposed ALERT stage sites for the upper Pajaro watershed include two previous USGS gage sites, three real-time USGS gage sites, and one newly proposed stage monitoring site at Tequisquita Slough at Shore Road.

The previous USGS gage sites that are recommended to be used as ALERT stage sites are:

- Pajaro River near Gilroy: This site could provide valuable stage data regarding the combined flows of Llagas Creek, Millers Canal, and the upper Pajaro River (which includes Pacheco Creek and Tequisquita Slough flows). Currently, Pajaro River at Chittenden is the only ALERT stage site on the mainstem of the Pajaro River. Monitoring the Pajaro River mainstem upstream of the San Benito River and Chittenden would allow more timely analysis of peak flows from the upper watershed. Observing peak flows above Chittenden could increase flood warning times for the lower Pajaro watershed.
- Pacheco Creek near Dunneville: This site is currently being evaluated for rehabilitation in Phase IV of the Pajaro River Watershed Study (See *Task 4.4.4 Evaluation of Rehabilitation Options for Pacheco Creek near Dunneville and San Benito River at Willow Creek Stream Flow Gages* TM). A stage site would provide data on the sizeable Pacheco Creek subwatershed below the reservoir.

The current real-time USGS gage sites that are recommended to be used as ALERT stage sites are:

- San Benito River at Willow Creek School: This site is currently being evaluated for rehabilitation in Phase IV of the Pajaro River Watershed Study (See *Task 4.4.4 Evaluation of Rehabilitation Options for Pacheco Creek near Dunneville and San Benito River at Willow Creek Stream Flow Gages* TM). A stage site would provide data at the midway point on the San Benito River between Hernandez Reservoir and Hollister.
- Llagas Creek near Gilroy: This site is equipped with satellite capabilities for real-time data transmission, but flow thresholds would need to be developed to utilize this site for future ALERT data acquisition[47].
- Tres Pinos Creek near Tres Pinos: This site could be equipped with ALERT capabilities to identify river stage due to the large Tres Pinos watershed.

The sixth proposed site, which is not associated with any USGS gage site, is Tequisquita Slough at Shore Road. This site would account for flow draining Santa Ana Creek, Arroyo Dos Picachos, and Tequisquita Slough. No field visits were conducted to determine the feasibility of this site for ALERT purposes. Therefore, further investigation is needed to determine the adequacy of the Tequisquita Slough at Shore Road as a gaging site.

[47] Stumpf, 2005.

Lower Pajaro River Watershed

In the lower Pajaro River watershed (downstream of Chittenden), three new ALERT stage sites are proposed for consideration. These three sites are currently monitored by the City of Watsonville (City) River Monitoring System. The equipment at each site monitors that particular river's stage, and each is maintained by the City's Department of Public Works and Utilities[48]. Two of these sites, Pajaro River at Watsonville and Salsipuedes Creek below Highway 129, are located within the leveed sections of these rivers and both are previous USGS gage sites. The third site, Salsipuedes Creek at East Lake Avenue, is located north of Watsonville, upstream of the creek's confluence with the College Lake drainage.

Conclusions

An Automated Local Evaluation in Real Time (ALERT) system is a valuable tool in enhancing the flood forecasting capabilities of local agencies. The real-time nature of these cooperative, community-operated flood warning systems provides a tool by which local hydrology program managers can evaluate rainfall, flow, and stage data for the potential of flooding.

In this TM, the existing ALERT capabilities of the local agencies in the Pajaro River watershed have been identified and the accuracy of the entire system has been explored. In doing so, gaps in ALERT coverage were identified and additional ALERT sites have been proposed.

The Pajaro River watershed is monitored by 25 existing ALERT gages and all local ALERT systems were reported as accurately functioning, pending indication otherwise. Fifteen new ALERT sites have been proposed to enhance the coverage of the existing monitoring systems.

Recommendations

Prioritization of the proposed ALERT sites is recommended, as implementing additional monitoring sites incurs additional costs to local agencies. Although site prioritization can take into account any number of parameters, some of these could include the following: site characterization (such as elevation, vegetation, aspect, slope), data history (if previous monitoring site), ease of access and installation, communication barriers (if line-of-sight needed), latest technology/equipment for accurate data acquisition (such as satellite capabilities), and operations and maintenance cost, among others. Furthermore, an ALERT site implementation approach could be developed based on the prioritization and funding available.

[48] Garrett, Dewey. City of Watsonville Department of Public Works and Utilities. January 5, 2005. Personal communication via telephone.

Whether or not each site needs to provide real-time data should be explored. In some cases, agencies provide near real-time or somewhat delayed (1-4 hours) information via the internet, which may be adequate at a particular site. For detailed information regarding optimum network design, site selection protocol and criteria, measurement techniques, and appropriate instrumentation, consult the National Hydrologic Warning Council[49] and the western ALERT Users Group[50].

More information remains to be collected regarding the existing ALERT systems within the Pajaro River watershed. Such information includes accurate station location (Latitude/Longitude) and elevation information, transmitting and receiving frequency information, and repeater and base station locations. Other helpful information to obtain would be radar information for areas of maximum precipitation and isohyetal and isopluvial maps generated from long-term climate stations[51]. The acquisition of this information would serve as a baseline from which to implement analyses and investigations toward developing a more effective ALERT monitoring system.

Further discussions and data collection and sharing should take place among all agencies involved. This would be beneficial in coordinating the Pajaro River watershed ALERT system as a whole to achieve the most effective flood forecasting capabilities throughout. Additionally, coordination and consultation with the western ALERT Users Group would provide valuable advice from experienced ALERT managers and users.

[49] National Hydrologic Warning Council. December 2004/January 2005. http://www.udfcd.org/Nhwc/
[50] ALERT Users Group. December 2004/January 2005. www.alertsystems.org
[51] ALERT Users Group. July 1995. ALERT Guidelines for the Collection of Hydrologic and Meteorologic Data. Version 2.2. www.alertsystems.org

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