

Flood Control District of Maricopa County



Final Technical Memorandum Cave Creek DMP Flood Response Plan

February 14, 2007

FCD 2004C072



In Association with:



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1. INTRODUCTION

The Flood Control District of Maricopa County (District) provides flood control facilities and floodplain management in the unincorporated portions of Maricopa County and participates in storm drainage projects and manages watercourses that traverse jurisdictional boundaries. The District has entered into an agreement with the Town of Cave Creek, Arizona (Town), to develop the Cave Creek Drainage Master Plan (DMP) to investigate flooding hazards and identify possible solutions to mitigate them. The study area covers approximately 50 square miles and is bounded by the Tonto National Forest to the north, the City of Phoenix to the south, the Town of Carefree to the east, and unincorporated Maricopa County to the west (**Figure 1**).

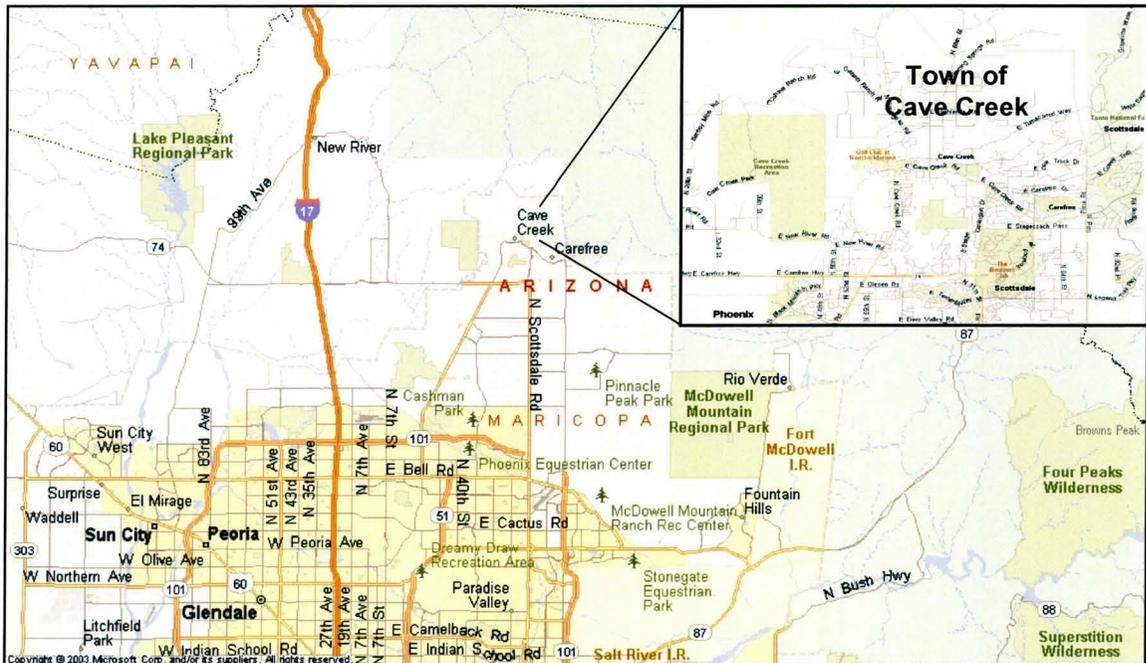


Figure 1: Cave Creek Flood Response Plan Location Map

Project Need

Cave Creek and its tributaries is an ephemeral drainage system that collects stormwater, provides habitat for numerous desert and riparian species, and is an important passive recreational resource for residents in northern Maricopa County. However, the Cave Creek system is also subject to flash flooding, and travelers are particularly susceptible to flooding hazards because there are numerous at-grade road crossings of the washes. The flash flood potential for the Town is presently exacerbated by the 2005 Cave Creek Complex Fire (USFS, 2005), which burned a portion of the upstream watershed. As a

result, the District and Town initiated a Flood Response Plan (FRP) for Cave Creek and tributaries within the DMP study area.

Project Authorization

This project was authorized in June 2006 by a subcontract between the prime consultant, HDR Engineering, Inc., and LTM Engineering, Inc., under its prime contract with the District, designated Contract FCD 2004C072.

Project Description

The Cave Creek FRP was developed for the following watercourse delineated segments within the Town boundaries:

- Cave Creek
- Willow Springs Wash and Tributaries 1, 2, 2A, 4, and 5
- Ocotillo Wash
- Rowe Wash
- Galloway Wash and North Tributary
- Andora Hills Wash

It is noted that Paradise Wash and its tributaries was originally included in the project Scope of Work. However, it was subsequently excluded from this FRP because it is within the Adobe Dam/Desert Hills watershed and was included in the District's Adobe Dam /Desert Hills FRP. It is noted that Apache Wash and Ranieri Tank Wash are also included in the Adobe Dam /Desert Hills FRP. (JEF, 2005)

2. FLOOD VULNERABILITY

Several flooding scenarios were evaluated for the potential to threaten property and the public during a storm:

- Major roadway crossings
- Local and collector street crossings
- Occupied structures constructed within the 100-year floodplain
- Recreational activities within the 100-year floodplain

Each of these scenarios is described below.

Major Roadway Crossings

Spur Cross, School House, and Cave Creek Roads traverse the Cave Creek drainage system and serve as the backbone of transportation routes within the Town. Most of the crossings are at-grade, i.e., stormwater crosses over the road in dipped sections rather than through a culvert or under a bridge. The locations of roadway flood vulnerability are identified in **Table 1**. Their locations are also shown on **Plate 1 - Locations of Flood Vulnerability**, included at the back of this memorandum. Photographs of selected locations are included in Attachment A.

Table 1: Access Concerns on Major Roadways

Road Crossing	Stream Name
Spur Cross Road	Cottonwood Creek @ confluence with Cave Creek Willow Springs Wash Willow Springs Wash Tributary 5 Ocotillo Wash Rowe Wash/Galloway Wash
School House Road	Ocotillo Wash Rowe Wash Galloway Wash Andora Hills Wash
Cave Creek Road	n/a (Andora Hills Wash is all-weather crossing)

Local and Collector Street Crossings

A number of local and collector streets traverse the Cave Creek drainage system, and nearly all of the crossings are at-grade. The locations of roadway flood vulnerability were classified according to major access (arterial streets) and minor access (local or collector streets). The locations are identified in **Table 2**. Their locations are also shown on **Plate 1 - Locations of Flood Vulnerability**, included at the back of this memorandum. Photographs of selected locations are included in Attachment A.

Table 2: Access Concerns on Local and Collector Roadways

Stream Name	Road Crossing
Willow Springs Wash Tributary 1	Spur Cross Road Morning Star Road Cahava Ranch Road
Willow Springs Wash	Sierra Vista Drive
Willow Springs Wash Tributary 5	Rockaway Hills Road Azure Hills Drive Highland Road
Ocotillo Wash	Echo Canyon Drive Continental Mountain Drive 72 nd Street Lone Mountain Road
Rowe Wash	73 rd Street Ridgeway Drive 62 nd Street
Galloway Wash	Ocotillo Ridge Drive
Galloway Wash N. Tributary	Grapevine Road
Andora Hills Wash	Skyline Drive Basin Road Mark Way Military Road Linda Drive Hidden Valley Drive/Ridge Road Habitat Circle Cave Creek Road Miramonte Drive (Note: low-flow culvert crossing)
Cave Creek	Morning Star Road Rockaway Hills Road Desert Hills Drive Ocotillo Road Creek Canyon Road

Occupied Structures within the 100-Year Floodplain

Aerial maps with superimposed delineated floodplains were reviewed to identify structures that could be threatened by a major flood. Fortunately, very few structures are currently shown within a floodplain, and they are concentrated in the Ocotillo Wash Zone A (approximate) portion of the delineated floodplain. This stream is currently being re-mapped as a detailed delineation by HDR, Inc., as part of the Cave Creek DMP, and it is anticipated that most of the structures in question will be outside the limits of the more detailed study.

Recreational Activities within the 100-Year Floodplain

Recreational activities within the floodprone areas are predominantly hiking and equestrian trails, including Cave Creek Recreation Area and the Spur Cross Ranch Conservation Area. Outside the designated passive recreation areas, numerous trails cross or are within the watercourses covered by the Cave Creek FRP. The trails typically follow existing roadways; therefore, flood vulnerability on recreational trails would coincide with the locations identified for roadways.

Gateway Desert Awareness Park is located within the Galloway Wash floodplain at Vermeersch Road. However, the Town noted that Vermeersch Road does not extend across the wash, and that there is a gate at the park that can be closed if needed. Additionally, the Town stated that park visitation is very low and has not been a source of concern.

3. FLOOD DETECTION

The District uses several sources of data to detect flood threats in Maricopa County, including the area within the Cave Creek DMP. Data sources include the District's automated precipitation, stage gage, and weather station network, radar and satellite products, National Weather Service (NWS) forecasts, and the Arizona Flood Warning System.

Weather Monitoring

The District's in-house meteorologist monitors satellite and radar data and NWS daily forecasts and uses this information to develop zone-specific forecasts for the County. If requested, the forecasts are made available to local jurisdictions by fax or email notification. The forecasts are used as an early "heads up" for flood threat within the County. The District has been providing this information to the Town by email and telephone.

In addition to the email and telephone notifications for an impending flood threat, normal operations of the District include a Daily Weather Outlook each afternoon for the next 24 hours, covering all zones including the New River/Cave Creek Zone. According to the District's Standard Operating Procedures, if meteorological conditions warrant, the following messages are delivered for individual zones:

- Message 1** Developing weather conditions may lead to flooding and/or destructive winds. Lead time will generally be 1 to 3 hours in advance of the expected event. The alert will normally include the zones to be affected, the time frame of the expected event, and the type of areas that will impacted - such as roads, washes, or streams.
- Message 2** Developing weather event may lead to flash flooding. Corresponds to a NWS Flood Watch. Lead time will generally be 1 to 2 hours in advance of the expected event.
- Message 3** Flash flooding is imminent or occurring. Corresponds to a NWS Flood Warning. Lead time will generally be less than an hour.
- Message 4** ALL CLEAR. Event no longer poses a threat and previous messages have expired or have been cancelled.

ALERT Gage Network Monitoring

The District monitors a sophisticated network of automatic rain gages, stream gages, and weather stations in and around Maricopa County. The network uses Automated Local Evaluation in Real Time (ALERT) technology to detect and monitor rainfall and runoff during storms. Monitoring of the system is continuous (24/7) by using threshold alarm features available onsite or by remote notification and access. Note that the area of focus of the FRP is the Cave Creek watershed, which extends past the boundaries of the Cave Creek DMP. Within the Cave Creek watershed, the following gages are being used to assess flood threat in Cave Creek:

<u>Device ID</u>	<u>Sensor Type</u>	<u>Name & Approximate Location</u>
4945/4948	Precip/Stage	<u>Cave Creek Fire</u> : at (stage) and near (precip) Cottonwood Creek outside the DMP study area 9 miles north of the Town
4920/4923	Precip/Stage	<u>Cave Creek @ Spur Cross</u> : at Cave Creek downstream of the Cottonwood Creek confluence
4890/4889	Precip/Stage	<u>Cave Creek @ Town Hall</u> : at Cave Creek west of the Town's municipal complex
4950	Precip	<u>Seven Springs</u> : 15 miles north/northeast of Cave Creek
4960/63	Precip/Stage	<u>Seven Springs Wash</u> : 11 miles northeast of Cave Creek
4940	Precip	<u>Humboldt Mountain</u> : 13 miles northeast of Cave Creek
5955	Precip	<u>Camp Creek</u> : 4 miles southeast of Seven Springs Campground

Unfortunately, aside from Cottonwood and Cave Creeks, there are no stage gages in the upstream watershed for direct monitoring of the other watercourses in the Cave Creek FRP.

Other Data Sources

The District is a partner in the Arizona Flood Warning System. Additional weather data are available from this source, including watershed conditions, US Geological Survey (USGS) streamgage data, and ALERT data from areas outside Maricopa County.

The NWS issues meteorological and hydrological forecasts and warnings to the public and to local jurisdictions. The forecasts and warnings include routine forecasts, special or severe weather forecasts and warnings, and stream or river forecasts. Two NWS offices provide this information to Maricopa County. First, the NWS Phoenix Weather Forecast

Office (WFO) issues flood and flash flood warnings and river and reservoir inflow forecasts for locations within Maricopa County and elsewhere. Second, the Colorado Basin River Forecast Center (CBRFC) in Salt Lake City, Utah prepares forecasts using computer-based river forecast models. At the District's request, the CBRFC has established two forecast points at existing gage sites along Cave Creek at the Spur Cross crossing and near Town Hall. NWS forecast information can be accessed from the Internet.

Evaluation of Current Notification Thresholds

Current thresholds in use by the District to monitor and notify the Town of impending flood threat are as follows:

<u>Device ID</u>	<u>Sensor Type</u>	<u>Name & Threshold</u>
4945	Precip	Cave Creek Fire: 0.5 inch in 30 min or 1.0 inch in 2 hours
4948	Stage	Cave Creek Fire: 4.7 feet (1,000 cfs)
4920	Precip	Cave Creek @ Spur Cross: 1.0 inch in 1 hour
4923	Stage	Cave Creek @ Spur Cross: 5.75 feet (575 cfs)
4890	Precip	Cave Creek @ Town Hall: 1.0 inch in 1 hour
4889	Stage	Cave Creek @ Town Hall: 3.5 feet (1,000 cfs)

Major road crossings of the various washes were identified in consultation with Town staff as follows:

Major Road

Spur Cross

School House

Grapevine

Wash Crossing

Willow Springs Wash Tributary 1
Willow Springs Wash (mainstem)
Ocotillo Wash
Rowe Wash/Galloway Wash confluence

Ocotillo Wash
Rowe Wash
Galloway Wash
Andora Hills Wash

Galloway Wash North Tributary

Stormwater depths, velocities and peak discharges for various storm events were provided by HDR Engineering, Inc., for use in the evaluation. It is noted that hydrologic

and hydraulic data were not available at all locations. Discharge characteristics for the available locations are summarized in **Table 3**.

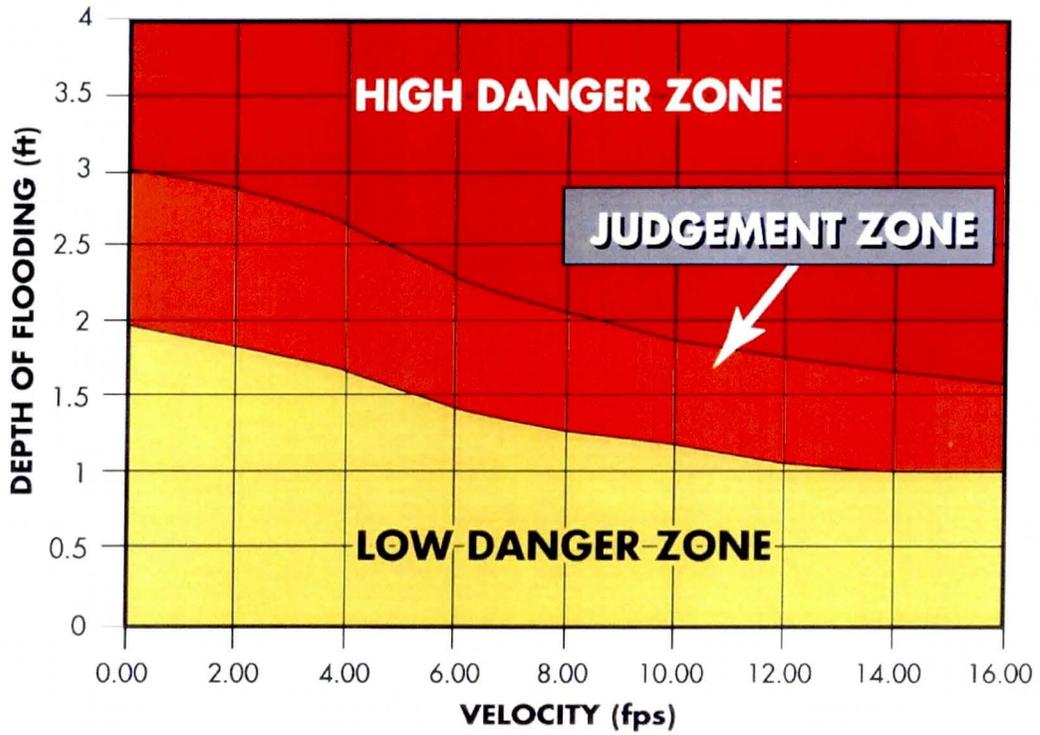
Table 3: Discharge Characteristics at Major Road and Wash Crossings

Road	Wash Crossing	Storm Event	Peak Discharge (cfs)	Time to Peak (hrs)	Depth of Peak (ft)	Velocity of Peak (fps)
Spur Cross	Willow Springs Trib. 1	10-yr	604	2.0	1.9	6.1
		100-yr	1,065	2.0	2.4	7.0
	Willow Springs	10-yr	4,800	1.33	2.9	9.8
	Ocotillo	100-yr	5,220	n/a	n/a	n/a
	Rowe/Galloway Confluence	10-yr, 6-hr	5,790	5.0	n/a	n/a
		100-yr	11,371	4.9	8.3	4.5
School House	Andora Hills	10-yr	1,031	4.4		
		100-yr	2,624	4.3	5.0	10.4
Grapevine	Galloway N. Trib.	10-yr	2,892	n/a	n/a	n/a
		100-yr	5,300	n/a	n/a	n/a

Data Sources: Cave Creek/Carefree Floodplain Delineation Study (CH2MHill, 1990)
 Cave Creek above Carefree Highway Floodplain Delineation Study (Sabol, 1997)
 FIS of Unincorporated Areas of Maricopa County (Harris-Toups, 1979)
 Floodplain Delineation Study of Galloway and Andora Hills Washes JEF, 1995)

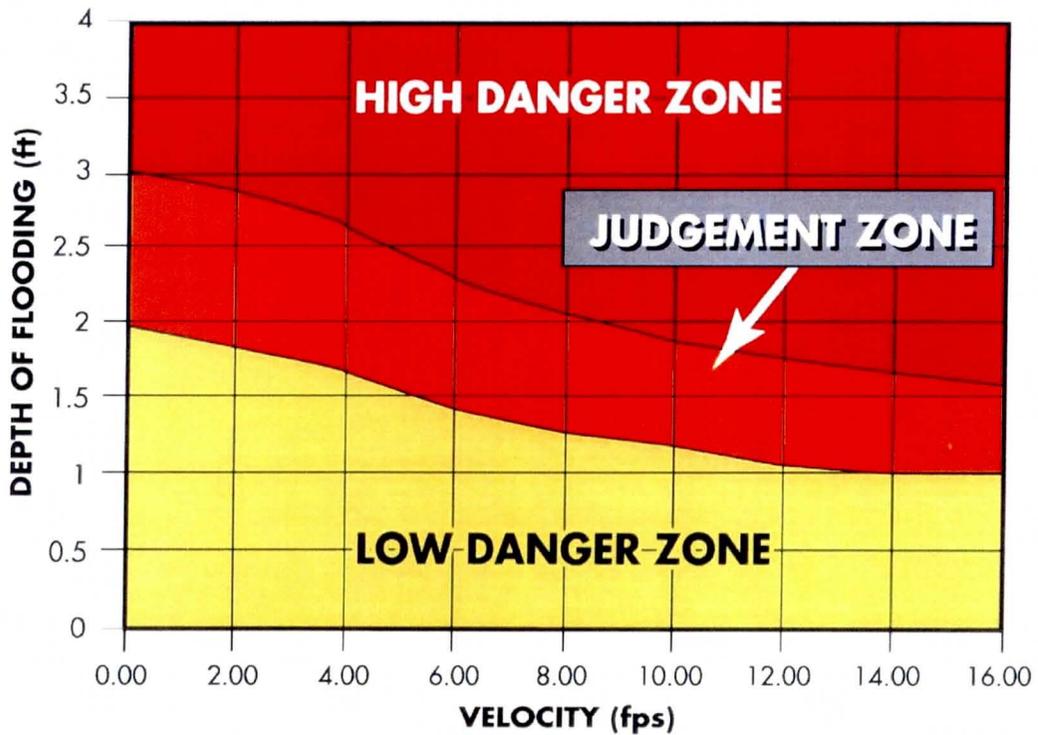
LTM Engineering subsequently compared the discharge characteristics with flood hazard criteria developed by the U.S. Bureau of Reclamation (USBR, 1988) to establish available lead time and recommended notification thresholds. Available data were compared with the USBR thresholds for vehicles. The peak discharge for 10-year, 6-hour storm for Willow Springs Wash Tributary 1 fell into the intermediate hazard category termed “judgment zone”. All other data were well into the “high danger zone” category. Therefore, the precipitation distribution for the 10-year, 6-hour storm would be a reasonable starting point in addressing recommended thresholds.

The USBR chart for cars is included as **Figure 2**. The chart for adults is also included as **Figure 3** for reference.



SOURCE: USBR, "Downstream Hazard Classification Guidelines," 1988

Figure 2: Riverine Flood Hazard Chart for Cars



SOURCE: USBR, "Downstream Hazard Classification Guidelines," 1988

Figure 3: Riverine Flood Hazard Chart for Adults

Hydrologic data from the 1997 Flood Insurance Study for Cave Creek (Sabol, 1997) were evaluated by the District to estimate the effects on the watershed of the 2005 Cave Creek Complex Fire. The District calibrated the model by reducing the lag time by 50% and the hydraulic conductivity (XKSAT) parameter by 30% (Tucker, 2006). Unfortunately, the 10-year storm was not evaluated as part of the study, so the 10-year precipitation distribution was not available. Therefore, the highest 30-minute and 1-hour precipitation was evaluated from this data source instead. It was determined that the highest 30-minute was 1.62 inches and the highest 1-hour precipitation was 1.93 inches. These precipitation depths are significantly higher than the thresholds currently in use by the District. However, it is not recommended that they be raised. First, the data above are for a 24-hour storm distribution, not a 10-year storm, so the level of confidence in the values is reduced. Second, because of the significant impacts of the 2005 Cave Creek Complex Fire on watershed response to rainfall, the thresholds must be reduced at least for the next several years until storm rainfall and runoff data indicated that the watershed has sufficiently recovered.

Available Lead Time

Based on the limited hydrologic details available for the individual watercourses, the time from start of rainfall to peak is as short as 1.33 hours at the Spur Cross Road Crossing of Willow Springs Wash. The Town has stated that 45 minutes or more is needed to be able to place barricades. The District's early threshold criterion of 30 minutes is expected to provide the necessary lead time. However, this FRP includes early "heads up" notifications so that the Town can mobilize if needed prior to the start of significant rainfall. This will allow additional lead time up front during a flood threat.

4. DISSEMINATION OF INFORMATION

Good communication among the participating agencies is critical to the success of the Cave Creek FRP. The responsibilities of the entities involved are identified below.

District Responsibilities

An important function of the District is to monitor rainfall and runoff conditions through its county-wide real-time flood detection and data collection network to support its flood control facilities and local jurisdictions within the County. The District is responsible for notifying the Town of potential or occurring flooding within the Cave Creek DMP study area. The District provides available weather and flooding information to the Town and may offer opinions of flood threat based on the information it collects. Notification responsibilities include anticipated heavy storms that are likely to fill the washes and temporarily restrict passage. It is assumed that these coordination procedures will be incorporated in the District's Flood Emergency Response Manual (FERM).

Town Responsibilities

The Town is tasked with monitoring emergency situations within its boundaries and coordinating support, if needed, with the Maricopa County Sheriff's Office (MCSO). The Town is also responsible for notifying local residents that are potentially in harm's way. Finally, the Town of Cave Creek is responsible for notifying and coordinating with the Town of Carefree. Of particular concern are the mainstems and tributaries to Galloway and Andora Hills Washes because their upstream reaches pass through developed areas of the Town of Carefree prior to entering the Town of Cave Creek. Additionally, note that Ocotillo Ridge Drive crosses Galloway Wash North Tributary at the Cave Creek/Carefree boundary. The crossing itself is within the Town of Cave Creek, but the surrounding development is a gated community within Carefree.

Maricopa County Sheriff's Office Responsibilities

The Maricopa County Sheriff's office will assist with responding to a flood emergency if requested by the Town.

5. SPECIFIC TASKS

Specific tasks for the Flood Control District of Maricopa County and Town of Cave Creek are identified below. At the end of this section, the respective procedures are summarized in two flowcharts Refer to **Flowchart 1** for the District's procedures and **Flowchart 2** for the Town of Cave Creek's procedures.

Routine Operational Procedures

Flood Control District of Maricopa County. The Flood Control District of Maricopa County shall perform the following non-emergency functions:

- a. Review the Cave Creek FRP annually and notify the Town of Cave Creek of any revisions.
- b. Participate in annual practice drills conducted by the Town of Cave Creek.
- c. Prepare an incident report for internal use after a flood emergency has ended.

Town of Cave Creek. The Town of Cave Creek shall perform the following non-emergency functions:

- a. Review the Cave Creek FRP annually and distribute any revisions to the participants.
- b. Coordinate and conduct a practice drill annually prior to the start of the monsoon season to simulate a flood emergency. The Flood Control District of Maricopa County and Maricopa County Sheriff's Office shall be invited to participate.
- c. Within two weeks of the practice drill, hold a post-drill critique meeting with all participants of this FRP. Summarize input from the post-drill critique.
- d. Develop brochures or other printed and/or online material that explains the dangers of flooding within the Town of Cave Creek and what actions residents should take to reduce their risk of loss of life.
- e. Prepare an incident report after a flood emergency has ended.

Flood Condition Procedures

Flood Control District of Maricopa County. The Flood Control District of Maricopa County is responsible for the following tasks during a flood threat or actual flood event within the boundaries of the Cave Creek watershed:

- a. Monitor internal ALERT rainfall and runoff gages within the Cave Creek DMP watershed.
- b. Notify the Town of Cave Creek if any of the following conditions are met:
 - i. Adverse conditions could exacerbate flooding conditions in the event of a storm.

- ii. Precipitation sensors in the vicinity of the Town of Cave Creek indicate that rainfall has exceeded 1 inch within 1 hour and rain is expected to continue.
- iii. The Cave Creek Fire gage reaches 4.7 feet or 1,000 cubic feet per second (cfs).
- iv. The Cave Creek @ Spur Cross gage reaches 5.75 feet or 575 cubic feet per second (cfs).
- v. Storm conditions have subsided and the Cave Creek drainage system poses no further threat to lives or property within the Town limits (ALL CLEAR)

Town of Cave Creek. The Town of Cave Creek is responsible for the following tasks during a flood threat or actual flood event within the boundaries of the Cave Creek DMP:

- a. Monitor daily the weather information provided by the Flood Control District of Maricopa County over the Internet.
- b. Monitor incoming weather information from the National Weather Service and others.
- c. If telephone communications are interrupted, access weather information provided by the Flood Control District of Maricopa County over the Internet in 30-minute intervals. The Internet address for the District's online catalog of products is:

<http://156.42.96.39/alert/APC.pdf>

- d. If notified by the Flood Control District of Maricopa County that weather conditions may lead to flooding (MESSAGE 1), or that the National Weather Service has issued a flash flood watch for the area or the District has issued a MESSAGE 2 notification, perform the following:
 - i. Alert Town personnel to prepare for a potential flood emergency.
 - ii. Notify the Town of Carefree and coordinate activities with Carefree officials.
- e. If notified by the Flood Control District of Maricopa County that one or more of the identified washes is expected to flood (MESSAGE 3), dispatch Town personnel to furnish and erect traffic barricades at the corresponding major road crossings:
 - i. Spur Cross Road
 - Willow Springs Wash (mainstem)
 - Willow Springs Wash Tributary 1
 - Ocotillo Wash
 - Rowe Wash/Galloway Wash confluence
 - ii. School House Road
 - Ocotillo Wash
 - Rowe Wash
 - Galloway Wash
 - Andora Hills Wash

- iii. Grapevine Road
 - Galloway Wash North Tributary
- f. Notify the Town of Carefree of the MESSAGE 3 status and coordinate flood monitoring and response with Carefree officials.
- g. If the flood event exceeds the Town's resources, contact the Maricopa County Sheriff's Office and request assistance.

Post-Flood Procedures

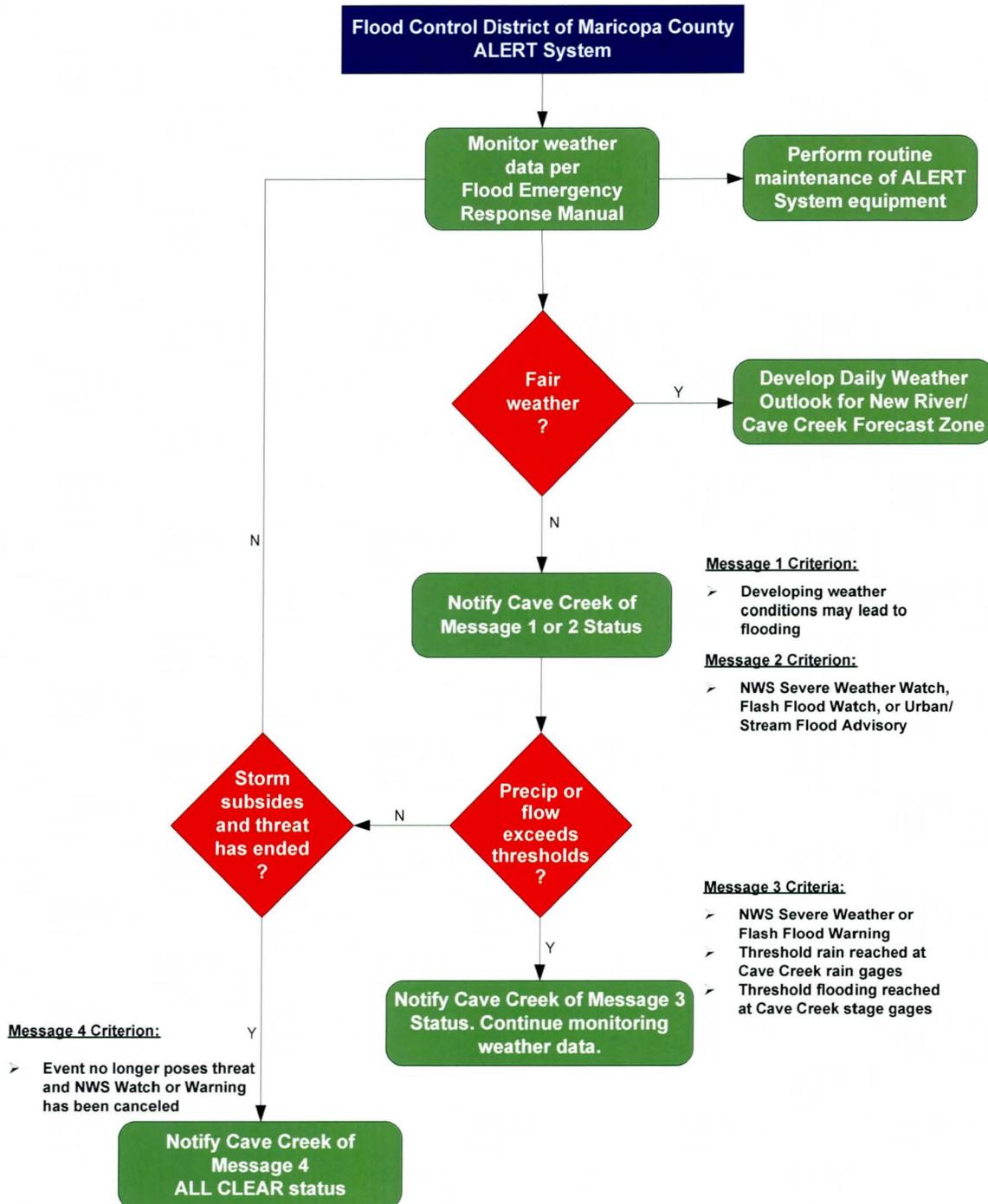
Flood Control District of Maricopa County. The Flood Control District of Maricopa County is responsible for the following post-flood actions:

- a. Follow its existing procedures of post-event inspections of any District structures, appurtenances, and gaging equipment.
- b. Prepare an internal after-action report on the flood event.
- c. Assess with the Town of Cave Creek the timeliness and usefulness of information provided.

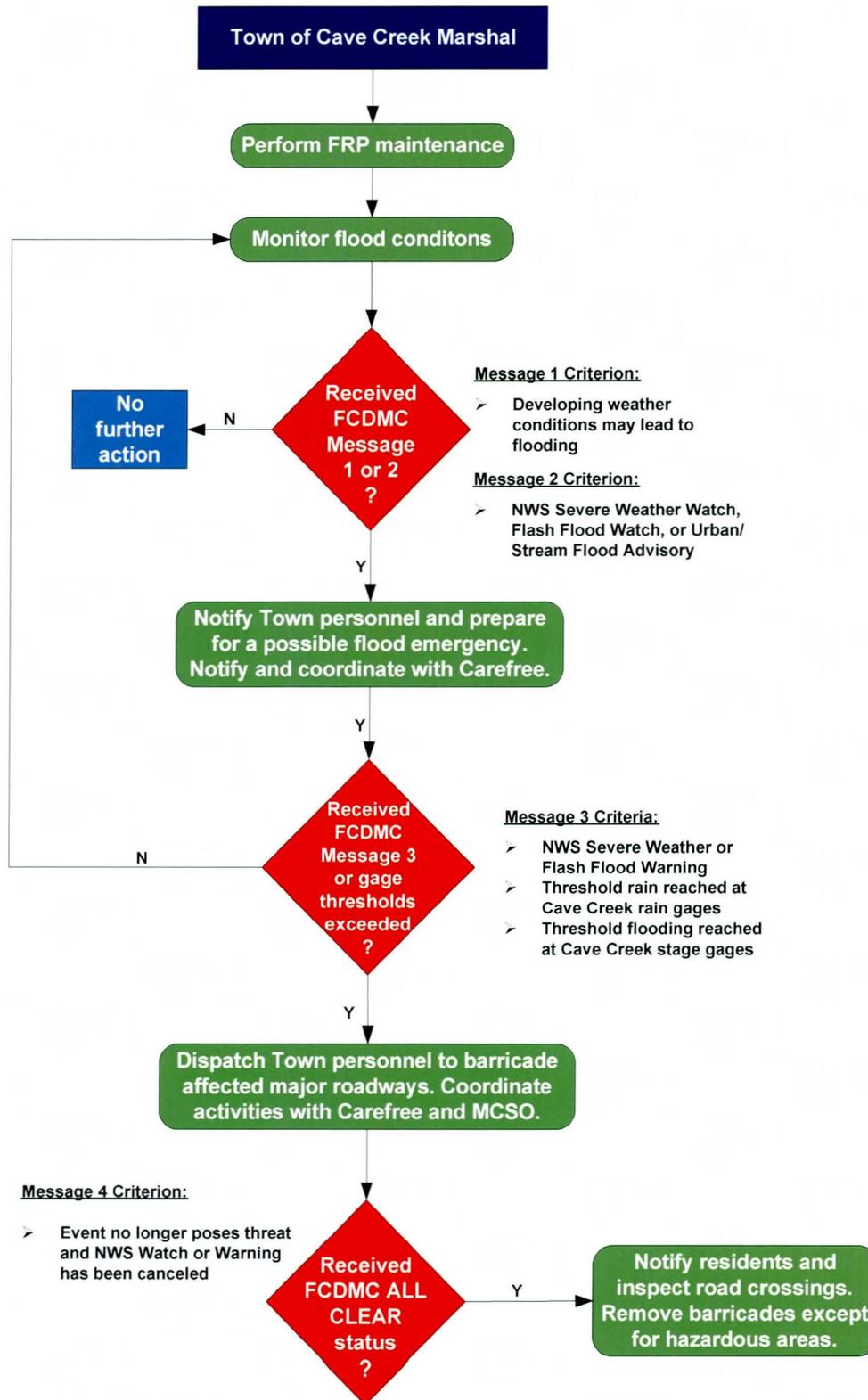
Town of Cave Creek. The Town of Cave Creek is responsible for the following tasks during a flood threat or actual flood event within the boundaries of the Cave Creek DMP:

- a. Notify Cave Creek residents of the "ALL CLEAR" status after a flood threat or flood emergency has ended.
- b. Inspect all major road crossings of washes and assess their suitability for resuming vehicular traffic.
- c. Remove and store any temporary traffic barricades placed in anticipation of flooded roadways, except as needed to restrict access to hazardous areas.
- d. Prepare an after-action report to assess its response to the event.
- e. Conduct a post-event meeting with the Flood Control District of Maricopa County.

Cave Creek Flood Response Plan Flood Control District of Maricopa County Procedures Flowchart 1



Cave Creek Flood Response Plan Town of Cave Creek Procedures Flowchart 2



6. TRAINING, EXERCISES, AND FRP UPDATES

The success of any FRP is dependent on the preparedness and coordination of its participants. The following tasks should be performed routinely to ensure that the Cave Creek FRP is effective in a real emergency.

Training

Initial training is recommended to incorporate the new FRP. Training would include a review of notification protocols, geographic coverage of each segment of the Cave Creek FRP (i.e., watercourses included and the associated drainage area), and road crossings of concern.

Exercises

Representatives from the Town, MCSO, and the District should attend and/or conduct periodic emergency management and response training. It is recommended that a tabletop exercise be conducted annually prior to the start of the summer monsoon season. In addition, it is recommended that all agencies meet after the monsoon season has ended to review the procedures and identify any necessary improvements to the Cave Creek FRP.

Cave Creek FRP Updates

As noted above, the Cave Creek FRP should be reviewed annually by the District and MCDEM and modifications should be made accordingly. In addition, it is recommended that the District concurrently review its Standard Operating Procedures and update as appropriate. Finally, it is recommended that the Town review its notification list annually to verify that contacts and phone numbers remain valid.

7. FUTURE IMPROVEMENTS TO THE CAVE CREEK FRP

Potential enhancements were evaluated for future changes that would affect the Cave Creek FRP.

ALERT Gage Network

As described previously, there are three precipitation/stage gages within the Cave Creek DMP watershed; two gages are along Cave Creek within the study area and the third, the Cave Creek Fire gage is within the Cottonwood Creek watershed. The Cave Creek Fire gage can be used directly to signify flood potential in Cottonwood Creek and its contribution to Cave Creek. However, monitoring of the remaining watercourses must rely on radar and satellite data with indirect confirmation from the Cave Creek Fire gage; there is no direct means of ground confirmation. Although this is sufficient for general storms covering large portions of the watershed, it is less reliable for small, intense storms that may concentrate to the south of the Cottonwood Creek drainage basin.

To improve the usefulness of warnings for the remaining drainage basins, it is recommended that additional precipitation/stage gages be installed. The gages could be co-located or separated, depending on the watershed characteristics and locations of stable stream sections such as an improved roadway section. Actual location of gages will be dependent on land ownership and availability, site access, vulnerability to vandalism, and the absence of obstructions rainfall capture. Potential locations of future gages for each of the tributary streams are described below. Although some stage gage sites are noted to have limited ability to enhance lead time, they remain an important component in the FRP as confirmation of impending flooding. Additionally, since the watershed characteristics dictate reliance on hydrologic predictions through the use of precipitation gage data, the stage gages will serve as an important calibration tool for the hydrology.

Andora Hills Wash. The contributing watershed has steep slopes littered with boulders and numerous side inlets. Additionally, there are limited hardened road crossings; most are gravel. Stage gages would provide confirmation of precipitation, but would provide only minimal additional lead time because of the relatively high velocities/short travel time. Precipitation data within or adjacent to the upstream watershed would facilitate narrowing the area of concern and subsequently aid in monitoring and emergency response.

The existing Stagecoach Pass precipitation/stage gage (ID 4910) in the adjacent watershed on Pima Road south of Cave Creek Road could be used to monitor general rainfall conditions for Andora Hills Wash. A new stage gage could be installed at the Tom Darlington Drive crossing as confirmation of runoff, but would not significantly increase available lead time.

Galloway Wash and Galloway Wash North Tributary. The existing Carefree Ranch weather station (ID 4930) located near the clubhouse could be used to monitor rainfall

conditions for Galloway Wash and Galloway Wash North Tributary. A new stage gage could be installed at the Charles Blair McDonald (Pima Road extension) crossing of Galloway Wash and at the Brangus Road crossing of Galloway Wash North Tributary. It is noted that these locations are within the gated Carefree Ranch in Scottsdale and could not be field-verified. However, since the District already operates and maintains a gage site within the development, it assumed that additional gages could be installed and maintained at or near these locations. Another potential stage gage location for Galloway Wash North Tributary is the Ocotillo Ridge Road crossing. The crossing is hardened and would be a good stage gage site. The crossing is in the Town of Cave Creek, but access is through a gated community within Carefree. However, lead time would be much shorter than the Brangus Road crossing.

Rowe Wash. Similar to Galloway Wash and Galloway Wash North Tributary, the existing Carefree Ranch weather station (ID 4930) could be used for precipitation data. Rowe Wash also crosses Brangus Road, which may be suitable for a stage gage.

Ocotillo Wash. There are limited opportunities for installing gages in the watershed upstream of Rowe Wash because it has very limited access and hardened crossings. One potential location for a stage gage may be on privately-owned land adjacent to Fleming Springs Road. The address listed by the Maricopa County Assessor is 43101 N. Fleming Springs Road and the parcel number is 202-17-002-J. The owner is listed as Gold Mountain LLC.

Willow Springs Wash The watershed contributing to Willow Springs Wash is much smaller than the adjacent Ocotillo Wash, and is similarly limited with respect to access and hardened crossings. One potential location for a stage gage is the crossing at the Echo Canyon Road extension just north of Fleming Springs Road. However, this location is close to developed areas and would serve to confirm precipitation in the watershed more than increase lead time. Access and stable road crossings are limited farther upstream.

Crest Gages

The Town and residents who have participated in the Cave Creek DMP have expressed interest in the installation of crest gages at selected roadway crossings. It is recommended that the Town install crest gages at the following roads where they cross the identified watercourses:

- Spur Cross Road
 - Willow Springs Wash Tributary 5
 - Willow Springs Wash (mainstem)
 - Ocotillo Wash
 - Rowe Wash/Galloway Wash confluence
- School House Road
 - Ocotillo Wash
 - Rowe Wash

- Galloway Wash
- Andora Hills Wash
- Grapevine Road
 - Galloway Wash North Tributary
- Creek Canyon Road
 - Cave Creek

Based on feedback from the Town and participating residents, the following attributes should be considered for the crest gages:

- Markings should be easily seen and interpreted from the approaching road.
- Flashing lights automatically activated by precipitation and/or stage data, with manual activation and deactivation capabilities. Consider two levels of warning lights, “warning”, and “do not cross”.
- Mark the crest gages to indicate unsafe crossing based on flood hazard charts developed by the U.S. Bureau of Reclamation.

Public Education

It is critical that Town residents be educated and/or reminded of the inherent flood hazards around them. Many residents have lived in the area for many years and are very familiar with the violent nature of flash floods. However, as the Town grows, new residents may be unfamiliar with the drainage characteristics and why it is important to avoid driving during significant rainfall events.

The Town posts public display boards at its municipal complex; it would be beneficial to have brochures available at this location. Information could include a map of the watercourses in Cave Creek with the at-risk roadway crossings identified and recommendations on what to do if it rains and how to interpret crest gages if they are installed in the future. In addition, it is recommended that the Town add a page to its website with similar information and links to the District’s flood detection and data collection website.

Notification Updates

Continued development within the watershed will dictate changes to the Town’s notification list. Currently, the Town notifies selected residents who have expressed a need for early notification because of animal care or access concerns. As the Town continues to grow, this list may need to be expanded or replaced by procedures that can better accommodate a larger notification list.

Additionally, one or more residents along Ocotillo Wash east of the Ridgeway Drive alignment may need to be added to the Town’s notification list. The area is currently designated to be within a Zone A floodplain, but conversion to a detailed (Zone AE) delineation is underway. If the new mapping shows inhabited structures within the 100-year floodplain, the owners should be notified and added to the Town’s notification list.

Coordination with Participants

Ultimately, the success of the Cave Creek FRP depends on close coordination among the participants because they are tasked with notification and barricading of streets at risk of flooding. Therefore, it is critical that all plan participants be given copies of the Cave Creek FRP, as well as electronic and/or full size prints of the flood vulnerability map and emergency access map. It is also critical that each copy of the FRP be tracked so that replacements may be issued to all as it is updated. The Town has been tasked with distribution and coordination of the FRP with its participants.

It is noted that there are several washes within the Cave Creek DMP boundaries on the west side of Cave Creek, including Apache, Paradise, and Ranieri Tank Washes. The Town expressed interest in notification for the Cloud Road crossings of these washes. As noted previously, these were not evaluated as part of the Cave Creek FRP because they were previously included in the District's Adobe Dam/ Desert Hills FRP (JEF, 2005). However, the Town of Cave Creek is not included on the notification list for this plan. Therefore, it is recommended that the District add the Town as a participant in the Adobe Dam/ Desert Hills FRP.

Analysis of Other Improvements (Not Recommended)

Several additional potential components were evaluated during development of the Cave Creek FRP:

- Automated road barrier arms
- Warning sirens
- Automated telephone notification systems

Automated road barrier arms are currently being tested by Maricopa County at another location. The barriers can be activated remotely and triggered by a signal such as a precipitation or streamflow threshold or manually on-site. The primary advantage is that roads can be closed quickly during a flood. However, participating residents did not support the tool because of the intrusive appearance in the desert environment. Town personnel supported a more passive rather than compulsory approach to road closures, and plans to continue the use of standard traffic barricades.

Warning sirens were considered initially but determined to be unsuitable for Cave Creek because they are very intrusive, do not target the specific safety concern of flooded roadways, and would need to cover a very large area.

Automated telephone notification systems were not supported by Cave Creek residents and do not address the specific flooding conditions within the Town. Essentially, the technology would provide little benefit because residents at home are already out of harm's way since there are no houses thought to be within the delineated 100-year floodplains. Additionally, the Town noted that it already provides an emergency notification system to interested residents known locally as the Code Red System. The

Town was concerned that implementing telephone for flood threat, which has inherent false alarms, could diminish the response to a major safety concern intended to be covered by the Code Red System.

8. REFERENCES

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George V. Sabol, Consulting Engineers, Inc., *Cave Creek above Carefree Highway Floodplain Delineation Study*, July 1997.

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U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines*, 1988.

U.S. Forest Service, *Watershed Assessment, Cave Creek Fire, Tonto and Prescott National Forests, Burned Area Emergency Response Team*, July 2005.

Attachment A
Selected Photographs of Vulnerable Locations



1. Fairway Trail bridge crossing of Andora Hills Wash



2. Miramonte culvert crossing of Andora Hills Wash



3. Habitat Circle crossing of Andora Hills Wash



4. Hidden Valley Drive/Ridge Road crossing of Andora Hills Wash



5 – 7: Basin Road crossing of Andora Hills Wash. Drainage cut off by new construction.



8 –10: Ocotillo Ridge Drive crossing of Galloway Wash. Deep, isolated canyon within gated Carefree community.



11: Grapevine Road crossing of Galloway Wash North Tributary



12: Vermeersch Road crossing of Galloway Wash at Gateway Desert Awareness Park w/ "No Thru Access" sign.



13: Ridgeway Drive crossing of Rowe Wash



14: 73rd Street crossing of Rowe Wash



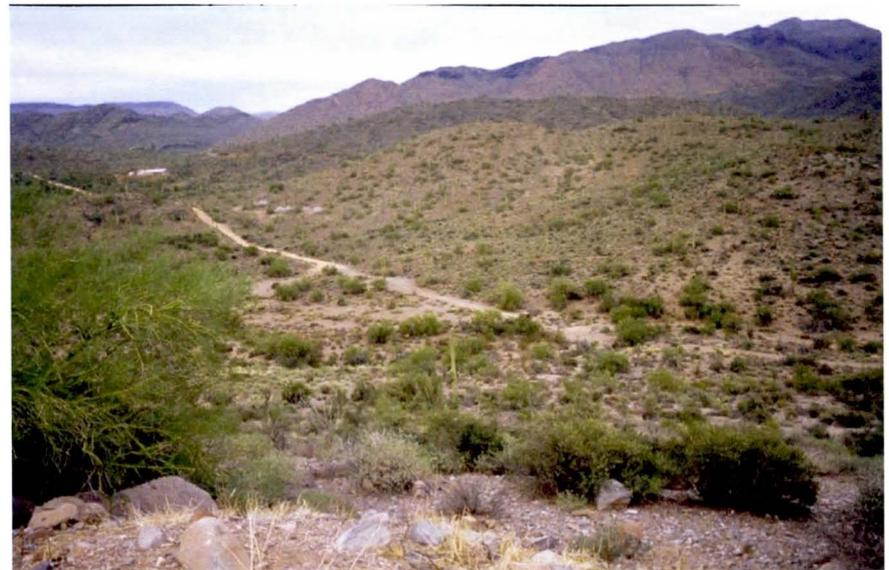
15: Rockaway Hills crossing of Ocotillo Wash near Echo Canyon Road



16: Continental Mountain Drive crossing of Ocotillo Wash



17: Echo Canyon Drive crossing of Willow Springs Wash (sign indicated road is Sierra Vista Dr.)



18: 72nd Street crossing of Ocotillo Wash



19-22: Rockaway Hills Road crossing of Willow Springs Wash Tributary 5. Structure(s) located immediately downstream of culvert that appears to be undersized.



23: School House Road crossing of Ocotillo Wash



24: Spur Cross Road crossing of Willow Springs Wash Tributary 5



25: Azure Hills Drive crossing of Willow Springs Wash Tributary 5

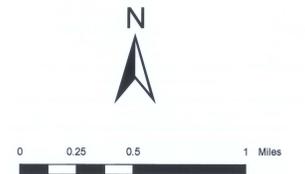
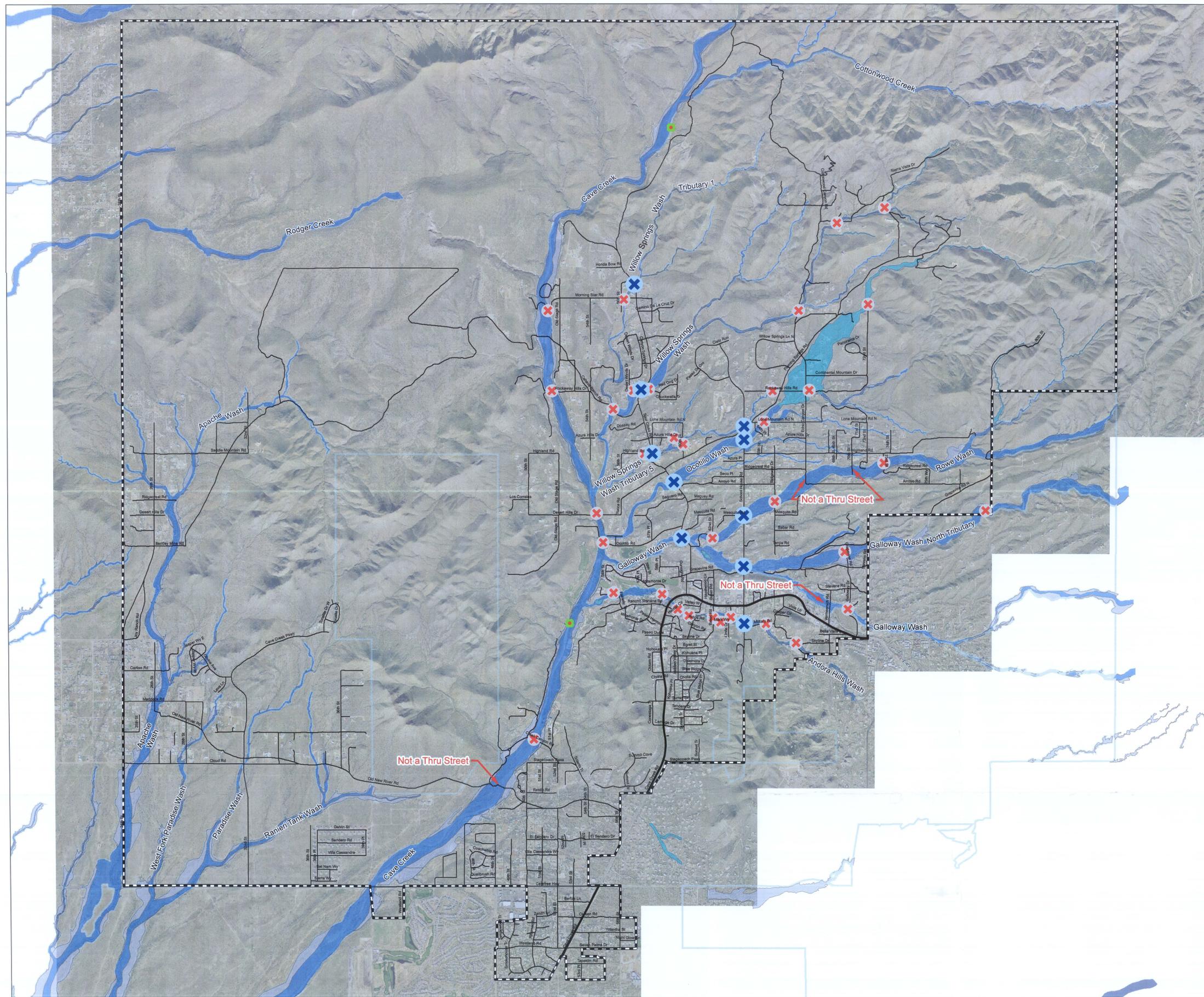
Attachment B
Notification Data

Cave Creek DMP Flood Response Plan Notification Data

(Data Provided Separately)

Cave Creek Flood Response Plan

Locations of Flood Vulnerability



Legend

- Major Street Crossing
- Minor Street Crossing
- Rain/Stream Gage
- Streets
- FEMA Zone X
- FEMA Zone AE
- FEMA Zone A
- FEMA Zone AH
- FEMA Floodway
- CCDMP Boundary



SETTLED 1870 · INCORPORATED 1966



Photo Source/Date: Flood Control District of Maricopa County 2005