2016

Pima County Multi-Jurisdictional Hazard Mitigation Plan

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TABLE OF CONTENTS

SECTION 1: INTRODUCTION **1**
1.1 Purpose **1**
1.2 Background and Scope **1**
1.3 Tribal Assurance **2**
1.4 Plan Organization **2**

SECTION 2: COMMUNITY DESCRIPTIONS **3**
2.1 County Overview **3**
4.2 Jurisdictional Overviews **11**
2.2.1 Marana 11
2.2.2 Oro Valley 15
2.2.3 Pascua Yaqui Tribe 17
2.2.4 Sahuarita 19
2.2.5 South Tucson 21
2.2.7 Tucson 23

SECTION 3: PLANNING PROCESS **26**
3.1 Planning Process **26**
3.2 Planning Team and Activities **26**
3.3 Public and Stakeholder Involvement **29**
3.4 Reference Documents and Resources **31**

SECTION 4: RISK ASSESSMENT **33**
4.1 Section Changes **33**
4.2 Hazard Identification **33**
4.3 Vulnerability Analysis Methodology **34**
4.4 Hazard Risk Profiles **39**
4.4.1 Disease 40
4.4.2 Drought 45
4.4.3 Earthquake 53
4.4.4 Extreme Temperature 60
4.4.5 Flood / Flash Flood 64
6.2.4 National Flood Insurance Program Participation 69
4.4.6 Hazardous Materials Incidents 71
4.4.6 Levee Failure 75
4.4.8 Severe Wind 79
4.4.9 Subsidence 83
4.4.10 Wildfire 89
4.4.11 Winter Storm 95
4.5 Risk Assessment Summary **99**

SECTION 5: MITIGATION STRATEGY **100**
5.1 Section Changes **100**
5.2 Hazard Mitigation Goals and Objectives **100**
5.3 Capability Assessment **100**
5.3 Mitigation Actions/Projects **120**

SECTION 6: PLAN MAINTENANCE PROCEDURES **134**
6.1 Monitoring, Evaluation and Updating **134**
6.3 Incorporation into Other Planning Mechanisms **136**

APPENDIX A: PLAN TOOLS 139

LIST OF MAPS

MAP 2-1: VICINITY 4
MAP 2-2: ECOREGIONS 6
MAP 2-2: COMMUNITY LOCATION AND LAND OWNERSHIP 7
MAP 2-3: GENERAL LOCATION AND TRANSPORTATION 9
MAP 2-4: TOWN OF MARANA LAND USE 12
MAP 2-5: TOWN OF ORO VALLEY LAND USE 16
MAP 2-6: PASCUA LOCATION 18
MAP 2-7: TOWN OF SAHUARITA GENERAL PLAN LAND USE 20
MAP 2-8: CITY OF SOUTH TUCSON LAND OWNERSHIP AND LOCATION 22
MAP 2-9: CITY OF TUCSON GENERALIZED DISTRIBUTION OF LAND USE PATTERNS 2001 24
MAP 4-1: U.S. DROUGHT MONITOR FOR OCTOBER 11, 2011 47
MAP 4-2: U.S. SEASONAL DROUGHT OUTLOOK, OCTOBER TO DECEMBER, 2011 48
MAP 4-3: ARIZONA SHORT TERM DROUGHT STATUS FOR AUGUST 2009 49
MAP 4-4: ARIZONA LONG TERM DROUGHT STATUS FOR JULY 2011 50
MAP 4-5: SOUTH-CENTRAL ARIZONA LAND SUBSIDENCE PROFILES 84
MAP 4-6: TUCSON ACTIVE MANAGEMENT AREA SUBSIDENCE 85
MAP 4-7: PCCWPP EXTRAORDINARY RAINFALL YEAR FUEL HAZARDS 92
MAP 4-8: WEATHER STATIONS WITH SNOWFALL WITHIN OR NEAR PIMA CO 96

LIST OF TABLES

TABLE 2-1: CLIMATE STATISTICS FOR STATIONS IN PIMA COUNTY 8
TABLE 2-2: POPULATION ESTIMATES 10
TABLE 3-1: PLANNING TEAM 26
TABLE 3-2: LOCAL PLANNING RESOURCES 28
TABLE 3-3: RESOURCE DOCUMENTS AND REVIEWED AND INCORPORATED IN THIS PLAN 31
TABLE 4-1: HAZARD IDENTIFICATION LISTS 33
TABLE 4-2: DISASTER COST FOR DECLARED EVENTS THAT INCLUDED PIMA COUNTY – 34
TABLE 4-3: CALCULATED PRIORITY RISK INDEX CATEGORIES AND RISK LEVELS 36
TABLE 4-4: ASSET INVENTORY STRUCTURES AS OF MAY 2011 37
TABLE 4-5: CPRI RESULTS FOR DISEASE 43

TABLE 4-6: CPRI RESULTS FOR DROUGHT 49
TABLE 4-7: EARTHQUAKE PGA, MAGNITUDE AND INTENSITY COMPARISON 53
TABLE 4-8: CPRI RESULTS FOR EARTHQUAKE 57
TABLE 4-9: POTENTIAL EXPOSURE AND LOSS FROM EARTHQUAKE HAZARD 58
TABLE 4-10: CPRI RESULTS FOR EXTREME TEMPERATURE 62
TABLE 4-11: CPRI RESULTS FOR FLOOD 66
TABLE 4-12: PIMA COUNTY EXPOSURE AND LOSS ESTIMATES DUE TO FLOODING 68
TABLE 4-13: NFIP STATISTICS AS OF AUGUST 31, 2011 69
TABLE 4-14: REPETITIVE LOSS PROPERTY STATISTICS FOR 69
TABLE 4-15: CPRI RESULTS FOR HAZMAT 72
TABLE 4-16: PIMA COUNTY EXPOSURE ESTIMATES DUE TO HAZMAT 73
TABLE 4-17: CPRI RESULTS FOR LEVEE FAILURE 76
TABLE 4-18: PIMA COUNTY EXPOSURE ESTIMATES DUE TO LEVEE FAILURE 77
TABLE 4-19: FUJITA TORNADO SCALE 81
TABLE 4-20: CPRI RESULTS FOR SEVERE WIND 81
TABLE 4-21: CPRI RESULTS FOR SUBSIDENCE 86
TABLE 4-22: PIMA COUNTY EXPOSURE ESTIMATES DUE TO SUBSIDENCE 87
TABLE 4-23: CPRI RESULTS FOR WILDFIRE 91
TABLE 4-24: PIMA COUNTY EXPOSURE AND LOSS ESTIMATES DUE TO WILDFIRE 93
TABLE 4-25: PROBABILITY ESTIMATES OF SNOWFALL DEPTH WITHIN OR NEAR PIMA COUNTY 97
TABLE 4-26: CPRI RESULTS FOR WINTER STORM 98
TABLE 4-27: HAZARDS TO BE MITIGATED BY EACH JURISDICTION 99
TABLE 5-1-1: PIMA COUNTY LEGAL AND REGULATORY CAPABILITIES 101
TABLE 5-1-2: PIMA COUNTY TECHNICAL STAFF AND PERSONNEL CAPABILITIES 106
TABLE 5-1-3: PIMA COUNTY FISCAL CAPABILITIES 106
TABLE 5-2-1: MARANA LEGAL AND REGULATORY CAPABILITIES 108
TABLE 5-2-2: MARANA TECHNICAL STAFF AND PERSONNEL CAPABILITIES 108
TABLE 5-2-3: MARANA FISCAL CAPABILITIES 109
TABLE 5-3-1: ORO VALLEY LEGAL AND REGULATORY CAPABILITIES 110
TABLE 5-3-2: ORO VALLEY TECHNICAL STAFF AND PERSONNEL CAPABILITIES 111
TABLE 5-3-3: ORO VALLEY FISCAL CAPABILITIES 111
TABLE 5-4-1: PASCUA YAQUI TRIBE LEGAL AND REGULATORY CAPABILITIES 112
TABLE 5-4-2: PASCUA YAQUI TRIBE TECHNICAL STAFF AND PERSONNEL CAPABILITIES 112

TABLE 5-4-3: PASCUA YAQUI TRIBE FISCAL CAPABILITIES 113
TABLE 5-5-1: SAHUARITA LEGAL AND REGULATORY CAPABILITIES 114
TABLE 5-5-2: SAHUARITA TECHNICAL STAFF AND PERSONNEL CAPABILITIES 114
TABLE 5-5-3: SAHUARITA FISCAL CAPABILITIES 115
TABLE 5-6-1: TUCSON LEGAL AND REGULATORY CAPABILITIES 116
TABLE 5-6-2: TUCSON TECHNICAL STAFF AND PERSONNEL CAPABILITITES 117
TABLE 5-6-3: TUCSON FISCAL CAPABILITIES 117
TABLE 5-7: MITIGATION RESPONSIBILITIES FOR THE PASCUA YAQUI TRIBE 118
TABLE 5-8: PREVIOUS MITIGATION PROJECTS RECEIVING FEDERAL MITIGATION FUNDING 119
TABLE 5-9-1: MITIGATION MEASURES FOR PIMA COUNTY 122
TABLE 5-9-2: MITIGATION MEASURES FOR MARANA 123
TABLE 5-9-3: MITIGATION MEASURES FOR ORO VALLEY 125
TABLE 5-9-4: MITIGATION MEASURES FOR PASCUA YAQUI TRIBE 128
TABLE 5-9-5: MITIGATION MEASURES FOR SAHUARITA 130
TABLE 5-9-6: MITIGATION MEASURES FOR TUCSON 132
TABLE 6-1: PASCUA YAQUI TRIBE PLANNING EFFORTS FOR FUTURE INTEGRATION 138

SECTION 1: INTRODUCTION

1.1 Purpose

The purpose of the Plan is to identify hazards that impact the various jurisdictions located within Pima County, assess the vulnerability and risk posed by those hazards to community-wide human and structural assets, develop strategies for mitigation of those identified hazards, present future maintenance procedures for the plan, and document the planning process.

Pima County and all of the Cities and Towns are political subdivisions of the State of Arizona and are organized under Title 9 (cities/towns) and Title 11 (counties) of the Arizona Revised Statutes (ARS).

The Pascua Yaqui Tribe is a federally recognized tribe, organized and established as a sovereign nation pursuant to the provisions of the Indian Reorganization Act of June 18, 1934. The Pascua Yaqui Tribe achieved federal recognition as an established tribe on September 18, 1978 and became recognized as a historic tribe in 1994. In 1988, the tribe's first constitution was approved. The Pascua Yaqui Tribe is governed by a tribal council that is made up of eleven elected officials who are dedicated to the well being and advancement of the tribe as a whole.

Accordingly, each of the participating jurisdictions is empowered to formally plan and adopt the Plan on behalf of their respective jurisdictions.

1.2 Background and Scope

Each year in the United States, disasters take the lives of hundreds of people and injure thousands more. Nationwide, taxpayers pay billions of dollars annually to help communities, organizations, businesses, and individuals recover from disasters. These monies only partially reflect the true cost of disasters, because additional expenses to insurance companies and nongovernmental organizations are not reimbursed by tax dollars. Many disasters are predictable, and much of the damage caused by these events can be alleviated or even eliminated.

Hazard mitigation is defined by FEMA as "any sustained action taken to reduce or eliminate long-term risk to human life and property from a hazard event." The results of a three-year congressionally mandated independent study to assess future savings from mitigation activities provides evidence that mitigation activities are highly cost-effective. On average, each dollar spend on mitigation saves society an average of $4 in avoided future losses in addition to saving lives and preventing injuries (National Institute of Building Science Multi-Hazard Mitigation Council 2005).

Examples of hazard mitigation measures include, but are not limited to the following:

- Development of mitigation standards, regulations, policies, and programs
- Land use/zoning policies
- Strong building code and floodplain management regulations
- Dam safety program, seawalls, and levee systems
- Acquisition of flood prone and environmentally sensitive lands
- Retrofitting/hardening/elevating structures and critical facilities
- Relocation of structures, infrastructure, and facilities out of vulnerable areas
- Public awareness/education campaigns
- Improvement of warning and evacuation systems

Hazard mitigation planning is the process through which hazards that threaten communities are identified, likely impacts of those hazards are determined, mitigation goals are set, and appropriate strategies to lessen impacts are determined, prioritized, and implemented. This Plan documents the planning process employed by the Planning Team. The Plan identifies relevant hazards and risks, and identifies the strategy that will be used to decrease vulnerability and increase resiliency and sustainability.

This Plan was prepared pursuant to the requirements of the Disaster Mitigation Action of 2000 and the implementing regulations set forth in the Federal Register (hereafter, these requirements will be referred to collectively as the DMA2K). While the act emphasized the need for mitigation plans and more coordinated mitigation planning and implementation efforts, the regulations established the requirements that hazard mitigation plans must meet in order to be eligible for certain Federal disaster assistance and hazard mitigation funding un the Robert T. Stafford Disaster Relief and Emergency Act.

Information in this Plan will be used to help guide and coordinate mitigation activities and decisions for future land use. Proactive mitigation planning will help reduce the cost of disaster response and recovery to the community and its property owners by protecting structures, reducing exposure and minimizing overall community impacts and disruption. The community has been affected by hazards in the past and is thus committed to reducing future disaster impacts and maintaining eligibility for Federal funding.

This is a multi-jurisdictional plan that geographically covers the participating communities within the Pima County boundaries (hereinafter referred to as the planning area). The following communities participated in the planning process:

- Pima County
- Marana
- Oro Valley
- Sahuarita
- South Tucson
- Tucson
- Pascua Yaqui Tribe

1.3 Tribal Assurance

The Pascua Yaqui Tribe will comply with all applicable Federal Statutes and regulations during the periods for which it receives grant funding, in compliance with 44CFR 13.11(c) and the DMA 2000 requirement §201.7(c)(6), and will amend its plan whenever necessary to reflect changes in tribal or Federal laws and statutes as required in 44CFR 13.11(d).

1.4 Plan Organization

This Plan is organized as follows:

- Section 1: Introduction
- Section 2: Community Profile
- Section 3: Planning Process
- Section 4: Risk Assessment
- Section 5: Mitigation Strategy
- Section 6: Plan Maintenance

SECTION 2: COMMUNITY DESCRIPTIONS

2.1 County Overview

History

Pima County is located in southern Arizona and encompasses 9,184 square miles. The second largest of the four original counties, Pima County was created by the first territorial legislature for Arizona on November 8, 1864. As originally constituted, Pima County included almost the entire portion of the United States originally acquired from Mexico in the Gadsen Purchase. Over time, portions of Pima County were carved off to create Maricopa, Pinal, Cochise, and Graham Counties.

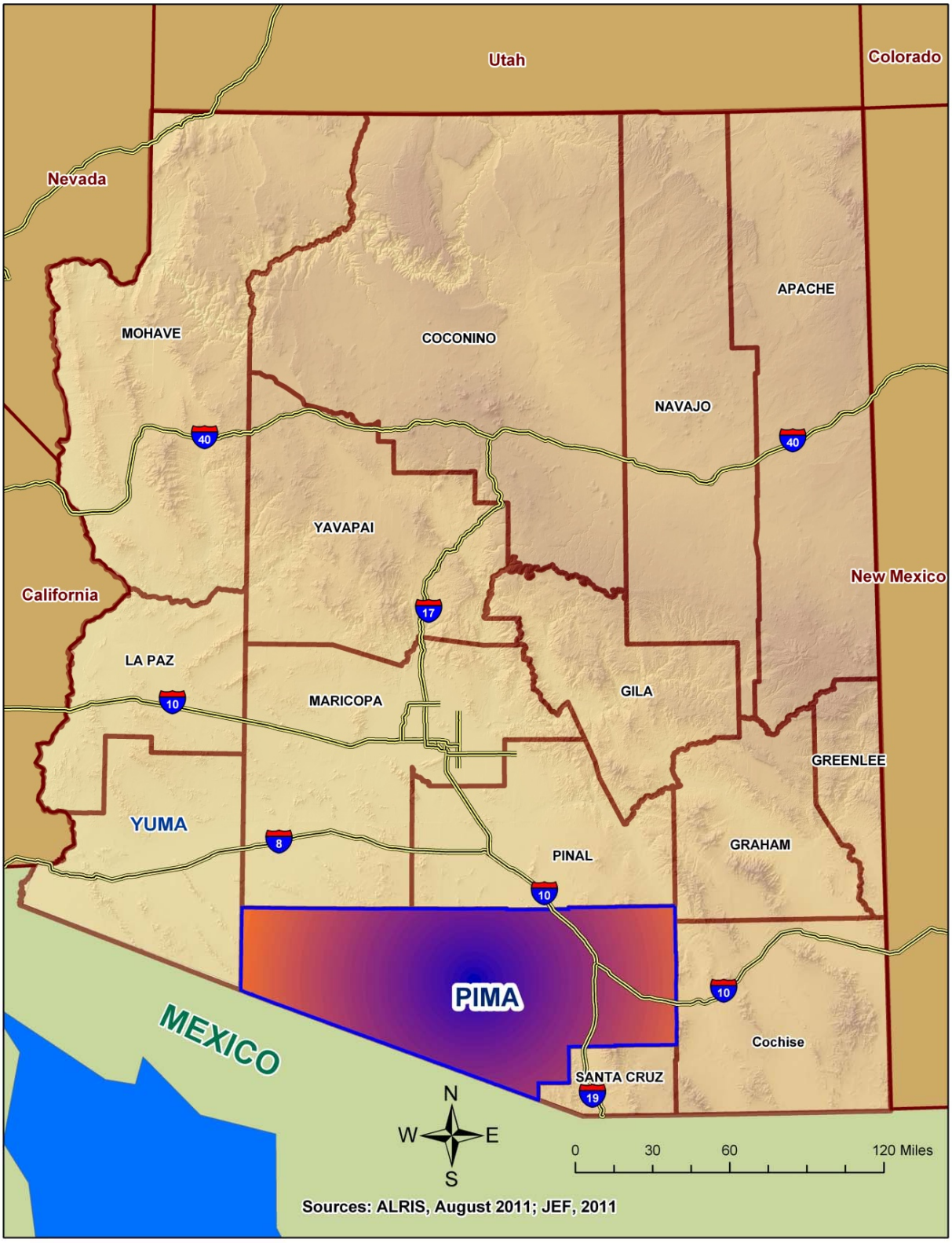
Originally named for the Native American tribe inhabiting the area, evidence of the human settlement of Pima County dates back over 9,000 years. The Hohokam inhabited the area until the 1500s when they mysteriously disappeared. The Tohono O'odham were the next to settle the region and concentrated along the Santa Cruz and Gila Rivers. The arrival of the Spanish in the 1690s marked the first European peoples to establish settlements in the area. Missionary and explorer Father Eusebio Francisco Kino established the San Xavier del Bac mission, which still stands today as one of the preeminent examples of 18th century missionary architecture in the world. Throughout the 1700s the Spanish continued to settle throughout southern Arizona. In 1775, the Tucson presidio was built to protect settlers from raiding tribes of Apaches. Residents of the fort began to refer to it as the "Old Pueblo", which still remains today as a nickname for Tucson.

Rapid growth in the region occurred in the mid-1800s with the discovery of silver and gold and the arrival of prospectors from Mexico. With the expansion of mining and ranching in the late 1800s, Pima County continued to witness increasing populations as new residents migrated to the Tucson region settling in proximity to major transportation corridors. Slowly, development moved eastward from Tucson until abutting with federally owned land resulting in a trend reversal with new growth occurring to the northwest.

Geography

Pima County lies within the Basin and Range Physiographic Province, characterized by northwest-trending mountain ranges separated by alluvial basins. Separated by the Tucson and Sierrita Mountains, a large portion of Pima County lies in two alluvial basins: Avra Valley to the west and the Tucson basin in the east. The regional drainage network, primarily formed by the Santa Cruz River and its tributaries, is dry for a majority of the year except during the spring runoff or from heavy storms.

Varying in elevation from desert valleys at roughly 1,200 feet to the 9,185-foot peak of Mount Lemmon, the county is home to diverse plant and animal communities. Numerous mountain ranges ring the Tucson basin, including the Santa Catalina, Rincon, Empire, Santa Rita, Sierrita, and Tucson mountains. Two cactus forests traverse the county – Saguaro National Park to the northeast and Organ Pipe Cactus National Monument in the southwestern portion. In addition, the County is home to the Cabeza Prieta National Wildlife Refuge nestled along the western boundary of the county and the Coronado National Forest in the eastern portion of the county within the Santa Catalina Mountains.



Map 2-1: Vicinity

Other major natural features include Tortolita Mountain Park, Tucson Mountain Park, Colossal Cave Mountain Park, Cienega Creek Natural Preserve, and Agua Caliente Park.

The geographical characteristics of Pima County have been mapped into the following three terrestrial ecoregions:

- **Chihuahuan Desert** – this ecoregion is typical of the high altitude deserts and foothills and is found in much of the southeastern portion of Arizona. Elevations in this zone varies between 3,000-4,500 feet. The average temperatures for the Chihuahuan Desert tends to be cooler than the Sonoran Desert due to the elevation differences. However, like its lower elevation cousin, the summers are hot and dry with mild to cool winters.
- **Sierra Madre Occidental Pine-Oak Forest** – this ecoregion is predominant to mountainous regions in southeast Arizona with elevations generally above 5,000 feet. The average temperatures tend to be cool during the summer and cold in winter.
- **Sonoran Desert** – this ecoregion is an arid environment that covers much of southwestern Arizona. The elevation varies in this zone from approximately sea level to 3,000 feet. Vegetation in this zone is comprised mainly of Sonoran Desert Scrub and is one of the few locations in the world where saguaro cactus can be found. The climate is typically hot and dry during the summer and mild during the winter.

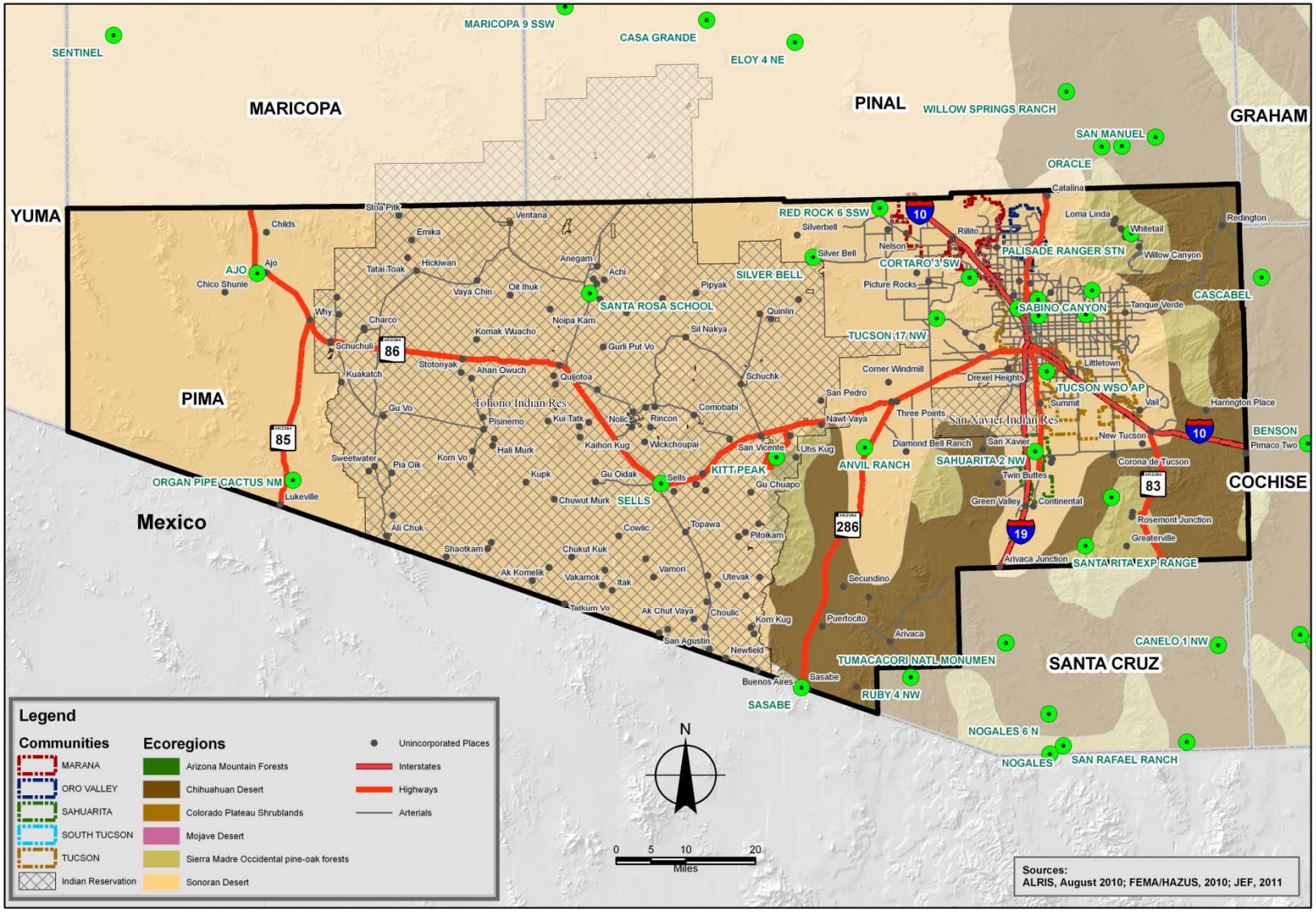
Land ownership within Pima County is divided between Indian Reservation (42%), Private (14%), U.S. Forest and Bureau of Land Management (12%), State Trust Land (15%), and other public lands (17%).

Government

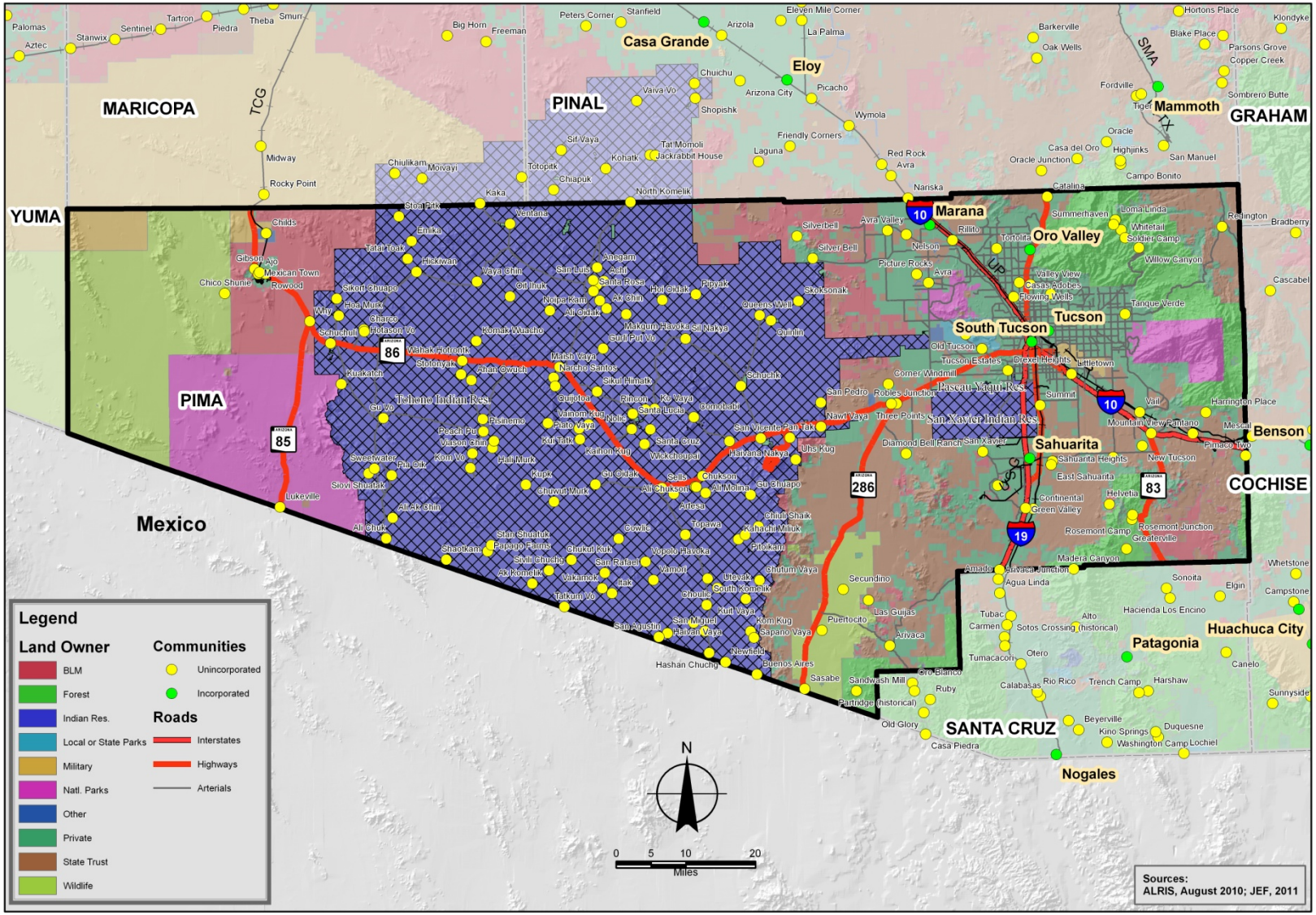
The governmental and administrative affairs of the unincorporated areas of Pima County are directed by a five-member Board of Supervisors with each member elected from a designated district to serve a four-year term. The chairperson is selected by the Board from among its members. Other elected officials, often referred to as constitutional officers, are the Assessor, Clerk of the Superior Court, the Constables, County Attorney, Recorder, School Superintendent, Sheriff, and Treasurer. Presiding judges are appointed from elected members of the judicial bench.

Because of Arizona's constitutional provisions and the requirements promulgated by Arizona Revised Statutes, the government of Pima County is organized to have a direct and indirect relationship with the Board of Supervisors. The Board of Supervisors has direct control over the County's general government functions; community services; indigent defense; medical, health, and welfare services; and public works functions. These broad functions include the County's internal governmental administrative/ management activities; maintenance and construction of the County's sewerage and sanitation infrastructures; County streets, roads, and bridges which comprise the County's transportation infrastructure; natural resources, parks, community centers, recreational facilities and libraries (in cooperation with the city of Tucson); and numerous clinics. Indirect relationships are maintained with the elected officials. The Board of Supervisors appoints a County Administrator to be responsible for the general direction, supervision, administration, and coordination of all affairs of the county.

Each of the five municipalities in the county (Marana, Oro Valley, Sahuarita, South Tucson, and Tucson) are governed by council-manager form of government, with an elected Council consisting of seven members, including a mayor and vice mayor and an appointed town or city manager. The Pascua-Yaqui Tribe is governed by an elected tribal council. Each of the municipalities and the tribal community are described in more detail in Section 4.3 below.



Map 2-2: Ecoregions



Map 2-2: Community Location and Land Ownership

Geology

Pima County is comprised of a complex geology reflective of a history of faulting and folding of the earth's crust. The mountains include sedimentary, metamorphic volcanic, or intrusive igneous rock, or a combination of the three. The alluvial basins consist of well-consolidated sediments eroded from the surrounding mountain ranges with caliche, or hardpan, underneath. Caliche is formed as calcium carbonate and deposited within the soil through water seepage.

Transportation

As shown in Figure 4-4, several major roadways support both local and transportation needs. Interstate 10 provides connectivity with the Phoenix metropolitan area to the north and Interstate 19 with Mexico to the south. Several other State and US highways, most notably Arizona State Highways 85 and 86, coupled with key Indian Routes provide local and regional access throughout southern Arizona. Pima County is host to four municipal airports providing commercial and general aviation service to the region. In addition, the county is home to the Davis-Monthan Air Force Base in Tucson. Davis-Monthan Air Force Base currently has approximately 6,000 military personnel stationed on base and employs 1,700 civilian persons.

Climate

For the majority of Pima County, the climate is typical to the Sonoran Desert areas of the state and is characterized by abundant sunshine, a long summer, mild winter, low average annual precipitation, relatively low humidity, and generally light winds. In the relatively small areas of the county above 4,000 feet mean sea level, the climate tends to be more moderate. Climatic statistics for weather stations within Pima County are produced by the Western Region Climate Center[1] and span records dating back to the early 1900's. Locations of reporting stations within or near Pima County are shown on Figure 4-2.

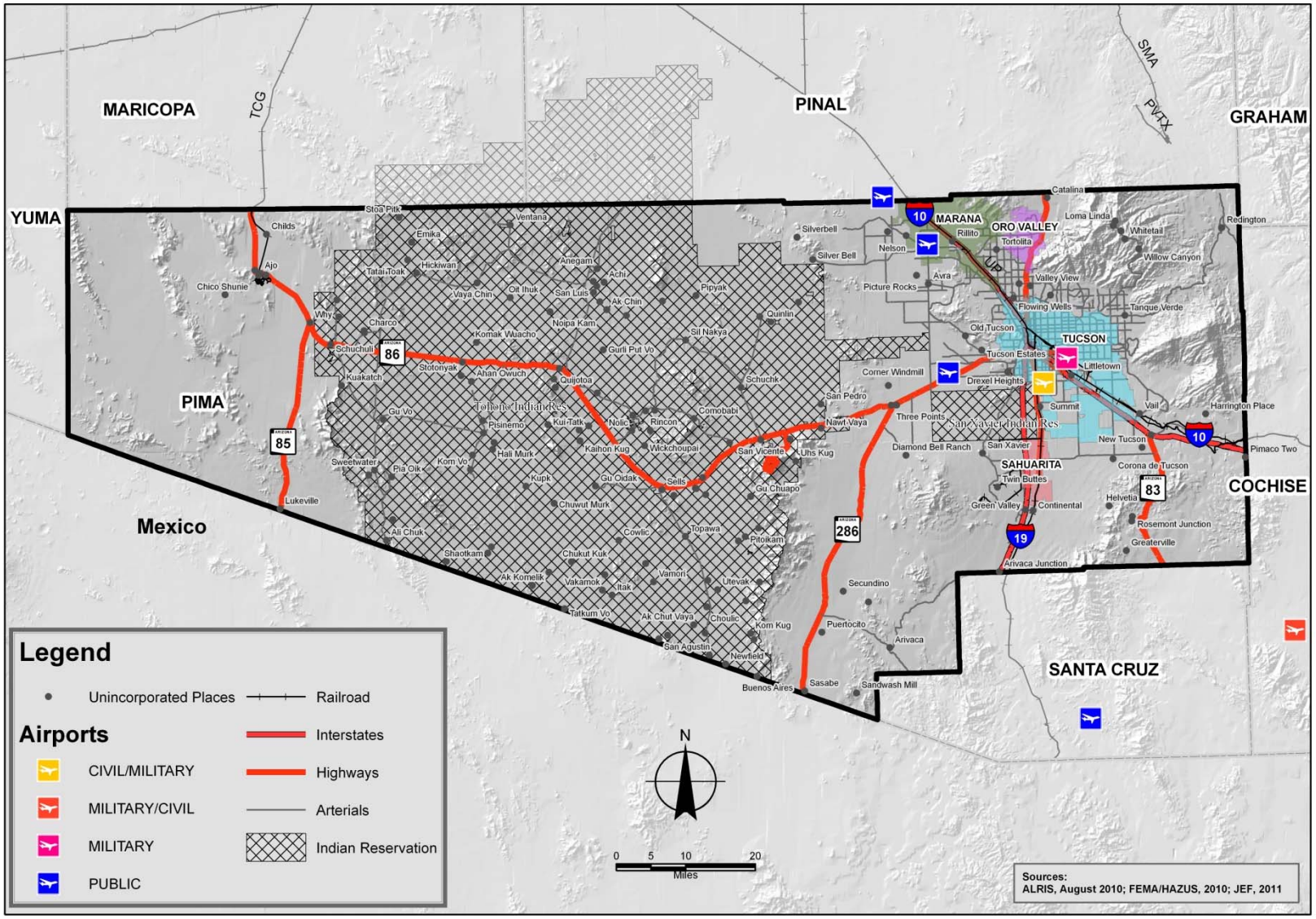
Table 4-1 lists some partial climate statistics for several of the weather stations located within the county. Average temperatures within Pima County range from near freezing during the winter months to over 100°F during the hot summer months. The severity of temperatures in either extreme is highly dependent upon the location, and more importantly the altitude, within the county. For instance, temperature extremes in the foothill communities will generally be about 10° less than those in the valley communities.

Table 2-1: Climate statistics for Stations in Pima County

	Average Temperature (F)				Precipitation (inches)		
	January		July				
Location	Min	Max	Min	Max	Wettest Month	Driest Month	Total Annual Average
Ajo	41.5	64	77.7	103	1.91 (August)	0.10 (May)	8.35
Cascabel	30.3	64.9	65.4	99.3	2.65 (August)	0.33 (May)	13.53
Kitt Peak	33.1	49.6	61.0	80.5	4.65 (August)	0.44 (May)	23.39
Sabino Canyon	37.1	66.4	72.4	101.9	2.41 (August)	0.19 (May)	12.73
Sahuarita 2 NW	31.0	67.0	68.4	101.3	2.57 (July)	0.06 (May)	10.62
Sells	36.9	66.0	72.1	101.1	2.58 (July)	0.15 (May)	11.77
Tucson Magnetic Observatory	34.2	64.8	71.3	100.5	2.25 (August)	0.24 (May)	12.62
Tucson, University of Arizona	37.6	65.5	73.9	100.1	2.15 (August)	0.18 (May)	11.14

Note: Period of record varies by station but generally spans from the early 1900's to 2010
Source: Western Regional Climate Center, 2011.

[1] Most of the data provided and summarized in this plan are taken from the WRCC website beginning at the following URL: http://www.wrcc.dri.edu/CLIMATEDATA.html



Map 2-3: General Location and Transportation

Precipitation throughout Pima County is governed to a great extent by elevation and season of the year. From November through March, storm systems from the Pacific Ocean cross the state as broad winter storms producing mild precipitation events and snowstorms at the higher elevations. Summer rainfall begins early in July and usually lasts until mid-September. Moisture-bearing winds move into Arizona at the surface from the southwest (Gulf of California) and aloft from the southeast (Gulf of Mexico). The shift in wind direction, termed the North American Monsoon, produces summer rains in the form of thunderstorms that result largely from excessive heating of the land surface and the subsequent lifting moisture-laden air, especially along the primary mountain ranges. Thus, the strongest thunderstorms are usually found in the mountainous regions of the central southeastern portions of Arizona. These thunderstorms are often accompanied by strong winds, blowing dust, and infrequent hail storms.[2]

Average wind speeds are similar across Arizona, averaging approximately 6 to 9 miles per hour annually. Pima County generally experiences average wind speeds at approximately 8 miles per hour. However, significant variations can exist throughout the year, as evidenced by Tucson's statewide record of 71 miles per hour maximum-recorded wind gust. The surrounding mountains and topography of the region influence wind velocities and directions in the Tucson basin.

Population

In 1775, Pima County's population was slightly more than 3,000. By 1920, the population had grown to over 20,000. According to the 2010 Census, 980,263 residents now call Pima County home, which reflects a growth of 16% since the 2000 Census. The majority of the citizens still live in the incorporated communities or reservation portion of Pima County. The largest community is Tucson. The two incorporated cities and three towns are geographically located in eastern portion of Pima County. The other unincorporated communities and places located throughout the county are usually situated along a major highway and are mostly comprised of only one structure or landmark.

Table 2-2: Population Estimates

Jurisdiction	1990	2000	2010	2015	2020
Pima County	666,880	843,746	980,263	1,175,967	1,271,912
Tribes, Cities and Towns					
Marana	2,187	13,566	34,961	60,809	72,915
Oro Valley	6,670	29,700	41,011	50,222	54,134
Pascua Yaqui Tribe (Pascua Pueblo Reservation)	2,412	3,315	3,745	-	-
Sahuarita	1,629	3,242	25,259	57,367	71,479
South Tucson	5,093	5,490	5,652	5,761	5,743
Tohono O'odham Nation	2,750	2,799	9,051	-	-
Tucson	405,390	486,699	520,116	597,568	624,671
Unincorporated County	247,540	305,049	340,468	404,240	442,969

Figures for 1990 & 2000 (1980–2008 Historical Estimates: http://www.azcommerce.com/econinfo/demographics/Population+Estimates.html
Figures for 2010 from AZ Dept of Commerce's AZ Workforce Informer: http://www.workforce.az.gov/?PAGEID=67&SUBID=255
Figures for 2015 and 2020 AZ Dept of Commerce's Arizona Workforce Informer: http://www.workforce.az.gov/?PAGEID=67&SUBID=257
2010 Pascua Yaqui Tribe and Tohono O'odham Nation estimates from 2010 Census Block data

Economy

The metropolitan Tucson area, located in the eastern portion of Pima County, is the center of economic activity for the County. As of August 2011, the county-wide labor force was estimated at 484,311 with an unemployment rate of 8.4%.[3] A majority of workers in Pima County are employed in the educational services, healthcare, and social assistance sector of the economy, followed by arts and entertainment, and then professional, scientific and management as illustrated in Figure 4-5. The labor force is reflective of the influence of tourism, academia, and the retirement population in the Tucson metropolitan area.

[2] Office of the State Climatologist for AZ, 2004. http://geography.asu.edu/azclimate/narrative.htm

[3] Source: AZ Dept of Commerce Office of Employment & Population, http://www.azstats.gov/pubs/labor/specrates2011.pdf

4.2 Jurisdictional Overviews

2.2.1 Marana

Nestled along Interstate 10 approximately 1 mile northwest of Tucson (see Figure 4-7), the Town of Marana experienced dramatic growth in the past decade as a result of aggressive annexation policies and the development of master-planned communities.

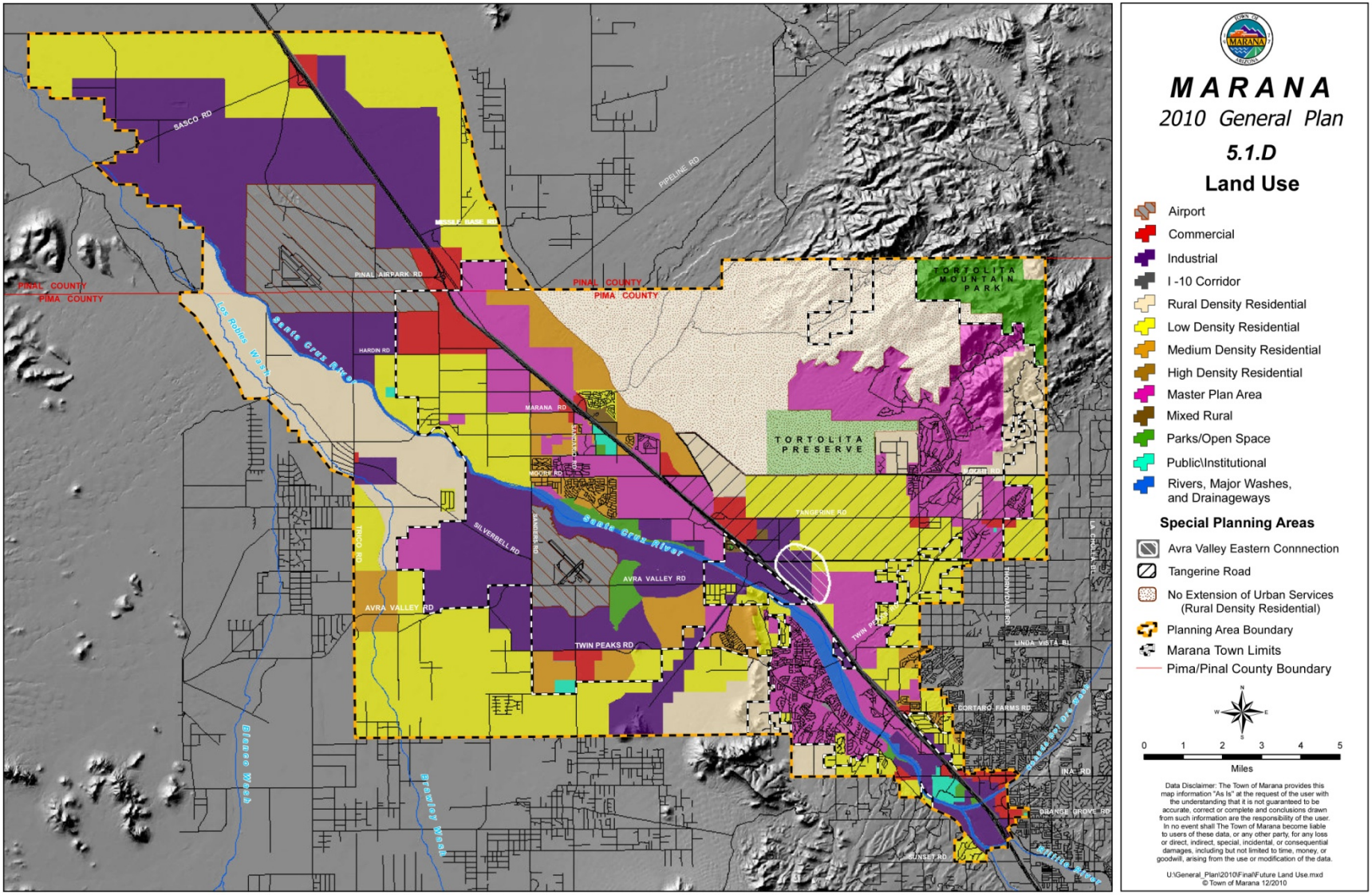
Founded in 1881, in conjunction with the development of rail transportation, Marana solidified itself as a destination with its appearance on Southern Pacific Railroad maps in 1890. Although ranching and the railroad dominated the community prior to World War I, the post-way war years brought significant change to the region with the implementation of extensive agricultural irrigation systems and the development of cotton farming. Other substantial factors in Marana's development were the location of Marana Army Air Field (now Pinal Airpark and Evergreen Air Center) and the removal of the downtown business district due to the widening of Interstate 10 in the early 1960's. In March of 1977, Marana incorporated with an area roughly 10 square miles. Governed by a seven member Town Council consisting of a Mayor and six council members elected for four-year terms, the Town utilizes a Council-Manager form of government. The Town Council appoints a Town Manager responsible for the daily operation of town services and the orderly administration of affairs.

Although a majority of Marana's topography is flat, much of the area is designated as floodplain. In addition, the existing Town boundaries include portions of the Tortolita and Tucson Mountain foothills that are dominated by slopes exceeding 15%. The development constraints posed by these environmentally sensitive lands provide the potential for natural open space and habitat conservation areas to balance with the urban development occurring. Several riparian features, including major wash crossing in the Tortolita Fan and the Santa Cruz River provide natural wildlife habitat for diverse species native to the Sonoran desert.

Although witnessing substantial urban growth during the past decade, Marana continues to hold onto its agricultural and ranching roots and serves as the main trade and transportation center for the surrounding rural periphery for the eastern portion of Pima County. As illustrated in Table 4-2, the 2010 Census population of Marana is 34,961. With residential development continuing to rise, this population is forecasted to grow to nearly 72,915 by 2020.

Marana's General Plan, adopted on December 7, 2010, reflects a community preparing for unprecedented future growth. Marana's Land Use Map defines a pattern of growth sensitive to the natural environment and reflective of the Town's goal to preserve and protect natural habitats. The Marana General Plan designates a majority of northeast Marana as environmentally sensitive, best suited for less intense uses such as low density residential development or open space. Low and medium density residential in proximity to environmentally sensitive areas provides a transition to more intensive commercial and industrial uses located in proximity to major transportation corridors including Interstate 10 and the Marana Northwest Regional Airport.[4]

[4] Pima County Multi-Jurisdictional Hazard Mitigation Plan, 2005



Map 2-4: Town of Marana Land Use

The Town's reputation for a business-friendly environment with no city property taxes has lead to substantial recent investment in economic development activities. Although agriculture remains a major force in Marana's economy, a recent influx of residential and commercial development has occurred due to its location between Phoenix and Tucson along I-10 and the Union Pacific Railroad, a business-friendly government and no town property taxes. To the south, adjacent to Tucson, is a new commercial business district. Continental Ranch/Peppertree Ranch Industrial Park has several new tenants and new industrial properties will soon be available at Marana Northwest Regional Airport. Marana's major private employers include Arizona Portland Cement, Costco, Home Depot, Wal-Mart, Lowes, Sargent Controls & Aerospace, and Tucson Ready Mix. Major public employers include the Marana Unified School District and the Town of Marana.

Marana's planning area encompasses approximately 228 square miles in Pima and Pinal Counties. Existing land uses include natural undisturbed desert, improved drainage areas, agriculture, recreational lands, residential, commercial, and industrial development. A majority of the Planning Area beyond the Town boundaries is undeveloped.

Marana's Town limits reflect the many changes and transitions that have occurred since its incorporation. Marana's rural heritage is reflected in traditional family farms and agricultural activities that continue on many acres of land historically used for agriculture. Older, low-density residential and commercial development was located west of Interstate 10, in and near the traditional Town area where many Marana pioneer families settled. This northwest part of Marana began a transition to a more densely populated area in early 2000. At that time, the Cactus Ferruginous Pygmy-owl was listed as an endangered species, which limited development in much of the area east of I-10. This shifted the development focus to the farm fields in northwest Marana. The extension of bank protection along the Santa Cruz River to Sanders Road took many of the farm fields out of the floodplain and opened them up to development opportunities. The extension of close to six miles of sewer lines in 2003 brought urban services to the northwest area. By 2010, there were more than 4,000 new lots platted in this developing part of the Town and close to half of those lots had constructed homes. The new growth brought approximately 5,000 new residents to this once rural area. The northwest area is the number one growth area for Marana, with more than 17,000 additional lots entitled in this area.

Marana's planning area includes natural areas, such as the Tortolita Mountain Alluvial Fan in the northeast, which provide physical constraints that limit development. Characterized by steep slopes, natural drainage ways, native vegetation and floodplains, this area provides natural undisturbed open space and habitat for a multitude of plant and animal species. The Town has proactively moved to direct new growth and development away from the fan to other more appropriate areas.

The Town of Marana 2010 General Plan indicates that residential development is the predominant land use, occupying more than 50% of the total land area. The residential categories provide a range of densities within each designation. However, the maximum density cannot always be achieved because of land use policies or physical constraints. Commercial and industrial uses may potentially accommodate a wide range of uses.

The new Twin Peaks Road extension and Twin Peaks/I-10 freeway interchange has created access and provided infrastructure to new areas previously unavailable for development. Related to this, Tangerine Road, from La Canada Drive to I-10, is currently in design for the expansion of up to six lanes which will facilitate the expected growth in three activity centers in the region:

1. The Tangerine Road/I-10 Activity Center;
2. The Tangerine Corridor Activity Center;
3. The Dove Mountain Activity Center.

The new Tangerine Road will eventually connect to a fully planned, new Tangerine/I-10 freeway interchange. These roadway projects will allow for the capacity necessary for future growth in the area as well as provide better circulation and connectivity in the community including access to the Town of Oro Valley.

At the Marana Regional Airport, a future focal point of the town's local economy, continual upgrading and expansion of the facility has added value to the airport and to the Town's ability to attract commerce. The recent addition of road and utility infrastructure in the 1-10 area directly east of the airport will attract new businesses to the Town while others will be attracted to the airport because of its business-class jet capabilities, convenient location and access for business or pleasure.

2.2.2 Oro Valley

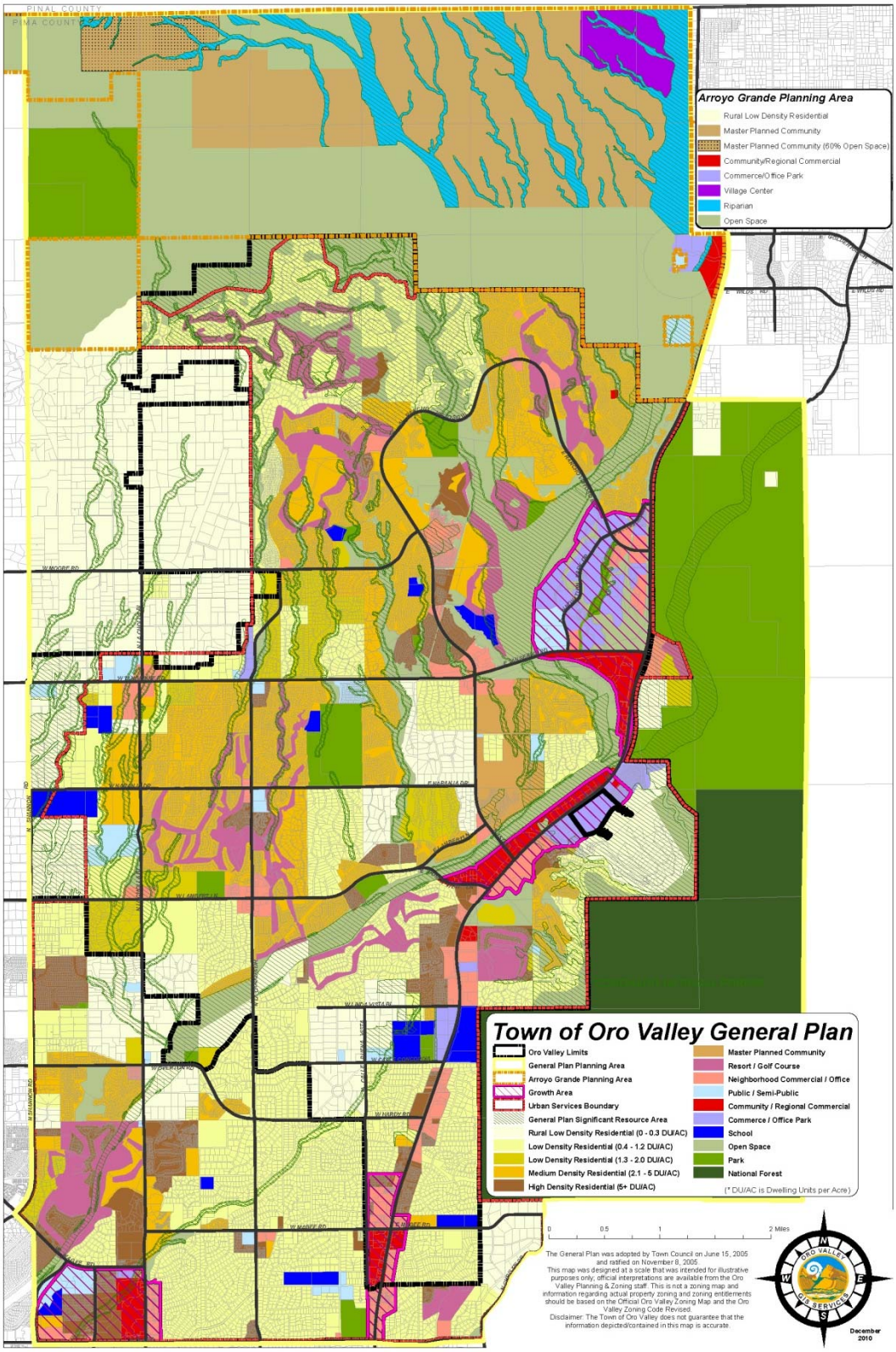
Located between the Santa Catalina Mountains to the east and the Tortolita Mountains to the northwest, Oro Valley is located six miles northwest of the Tucson city limits. Other nearby communities include the Town of Marana to the west and the unincorporated community of Catalina to the north. Oro Valley serves as a gateway to regional parks, sharing its eastern border with Catalina State Park and the Coronado National Forest. These areas provide vast recreational and natural open space opportunities for the community and are integral to the Town's identity as a community known for its integration of residential uses within the natural Sonoran Desert and as a resort area. Major access to Oro Valley is provided via Interstate 10, located approximately 12 miles to the west, and State Route 77, or Oracle Road, which runs north-south through the Town, and is the original transportation corridor linking Tucson with the Phoenix metropolitan area to the north. The Town was incorporated in April of 1974 and operates under a Council-Manager form of government, which includes a mayor and six council members elected at large. The Mayor is directly elected while the Vice Mayor is selected by the Council from among the six Council members.

The 2010 population of Oro Valley is projected at 41,011. With residential development continuing to rise, this population is forecasted to grow to nearly 54,134 by 2020. Presently, the community relies on residential growth and development to stimulate economic opportunities, which results in vulnerability to fluctuations in the real estate market. Oro Valley's large employers include: Ventana Medical Systems, a member of the Roche Group, the Hilton El Conquistador Golf & Tennis Resort, Oro Valley Hospital, Town of Oro Valley, Amphitheater School District, Fry's Food and Drug Store, Wal-Mart, Target and Kohl's. Oro Valley is emerging as a regional center for the biotech industry, with Innovation Park, featuring medical and biotech campuses.

The Town of Oro Valley General Plan, adopted by the Town Council on June 15, 2005, and ratified by the Oro Valley voters on November 8, 2005, supports the themes of maintaining low-density residential character while permitting a compatible mix of land uses and preservation of the natural Sonoran desert through the implementation of a well connected system of natural open space. Rural and low-density residential and open space uses predominate throughout the community, comprising 36.5% and 26.9% of the planning area, respectively, and tend to follow natural features and provide buffers to environmentally sensitive areas from high intensity uses. Commercial uses concentrate along Oracle Road, providing easy access to residential neighborhoods and resulting in a linear pattern of higher intensity uses.

As of August 2011, the civilian labor force was 19,637 with an unemployment rate of 5.9%. In 2008, there were approximately $830.2 million of taxable sales in the town. [5]

[5] http://www.azcommerce.com/doclib/COMMUNE/oro%20valley.pdf



Map 2-5: Town of Oro Valley Land Use

2.2.3 Pascua Yaqui Tribe

The lands of the Pascua Yaqui became part of the United States in the 1870s. Calling themselves the Yaquis, the first modern settlements of these descendents from the ancient Uto-Azteca people, were near Nogales and South Tucson. Over time, the Yaquis spread out, settling north of Tucson in an area they named Pascua Village and in Guadalupe near Tempe. Retaining their religious and cultural ways of life, the Yaquis began calling themselves the Pascua Yaqui Tribe and accepted political integration into American society during the 1950s. In 1952, the Pascua Yaqui Tribe was annexed by the City of Tucson. In 1964, Congress transferred 202 acres of desert land southwest of Tucson to the Pascua Yaquis who were looking for an area to preserve their tribal identity. Members of the Pascua Yaqui Tribe relocating to the reservation struggled to secure federal recognition for the tribe until finally being recognized in 1978. The Tribe acquired an additional 690 acres in 1988. In 1994, the tribe's status was changed from a created tribe to an historic tribe.

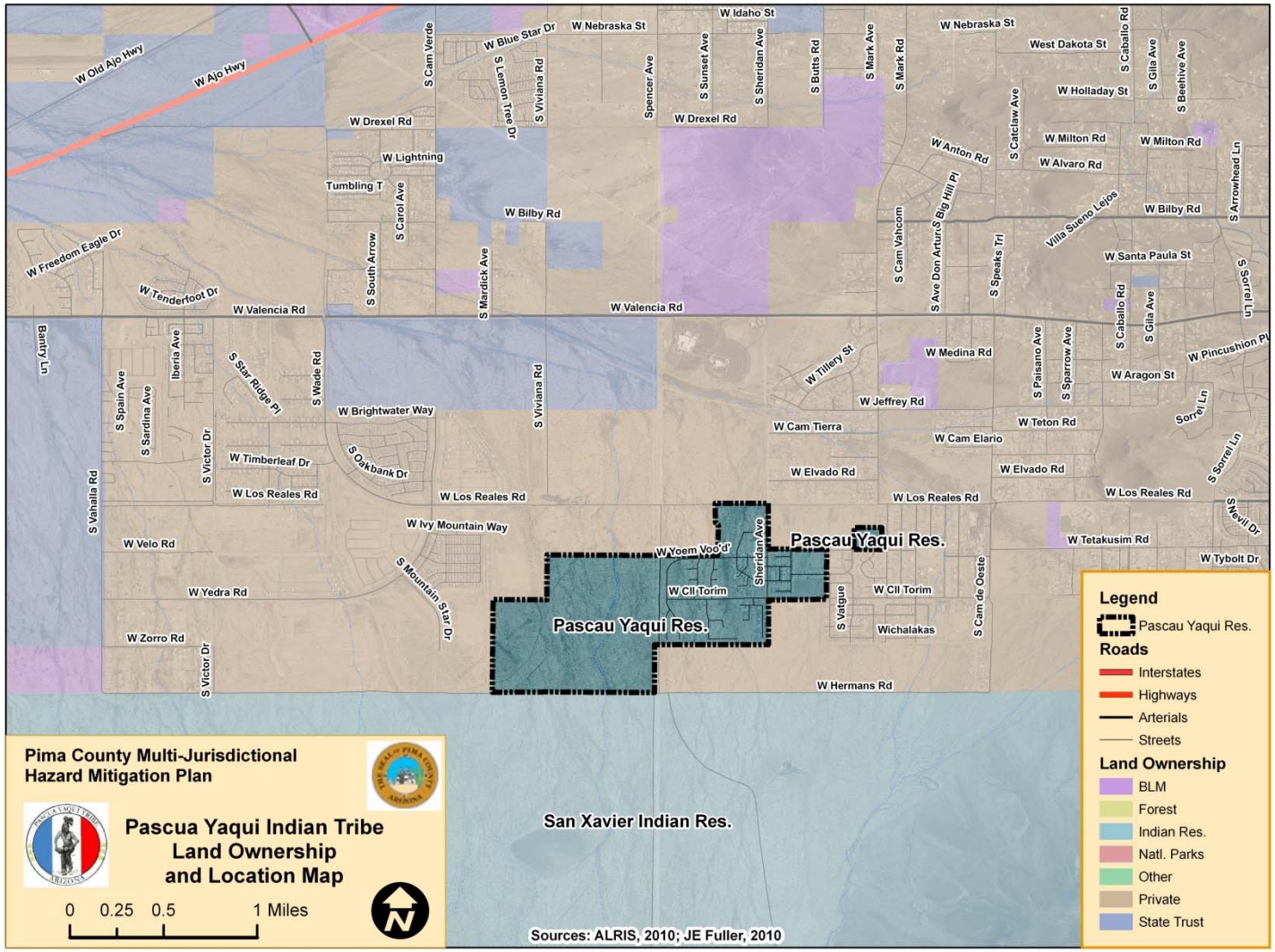
Today, the Pascua Yaqui Tribe is scattered throughout eastern Pima County and includes several small communities. These communities include Yoem Pueblo in Marana, Old Pascua in Tucson, Barrio Libre in South Tucson, and the Pascua Pueblo, a 1.87-square mile reservation located southwest of the City of Tucson.

According to Tribal sources, the population as of November 2011 for the Pascua Yaqui Tribe within Pima County communities was 4,592. Table 4-3 summarizes enrolled Tribal membership by the various Pascua Yaqui communities located both within Pima County and outside.

Table 2-3: Pascua Yaqui Tribal enrollment as of March 2011

Pascua Yaqui Communities	No. of Enrolled Members
• Pascua Pueblo (Reservation)	• 3951
• Old Pascua (Tucson)	• 418
• Barrio Libre (South Tucson)	• 174
• Yoem Pueblo (Marana)	• 49
• Guadalupe (Maricopa County)	• 3,313
• High Town (Chandler)	• 74
• Penjamo Pueblo (Scottsdale)	• 171
• Eloy/Coolidge (Pinal County)	• 256
Total (within Yaqui communities)	**8,406**
• Outside of Yaqui Communities	• 9,446
• In Arizona (Outside of Yaqui Communities)	• 9,737
• Outside the State of AZ	• 1,681
Total Active Membership	**17,852**

The Pascua Yaqui Tribe operates two casinos within Pima County, the 40,000 square foot Casino of the Sun and the 75,000 square foot Casino del Sol. Other tribal enterprises include the brand new Sol Casino Hotel and Convention Center, which includes 215 rooms and a 20,000 square foot ballroom, the Anselmo Valencia Amphitheater 4,470 seat open-air concert venue, and the Del Sol Marketplace.



Map 2-6: Pascua Location

2.2.4 Sahuarita

The Town of Sahuarita is the southern-most incorporated and newest jurisdiction within Pima County. Sahuarita was incorporated in 1994 and the Town population has increased 669% during the period between the 2000 and 2010 Census estimates. Situated along Interstate 19 approximately 15 miles from the City of Tucson, Sahuarita share portions of its southern border with the retirement community of Green Valley and its northern border with the Tohono O'odham Nation. Unincorporated Pima County surrounds the remainder of the Tow to the west and east. The Town of Sahuarita is known for its semi-rural setting with a mixture of master planned communities in contrast to the historical agricultural production sill largely occupying he east portion of the community. Bounded by mountain ranges within the Santa Cruz Valley, Sahuarita's resident are governed under a Council-Manager form of government, which includes a seven-member Town Council consisting of a Mayor and six Council Members elected at-large for overlapping terms of four years.

Sahuarita encompasses 30.5 square miles of area. The primary transportation corridors through the Town are Interstate 19 and the Tucson Nogales Highway (SR 19B) providing connections with the metropolitan environs of Tucson to the north and the Mexican board to the south. Paralleling the Tucson Nogales Highway, natural development constraints abound in Sahuarita as the Santa Cruz River and its associated floodplain effectively bisect the Town into eastern and western segments.

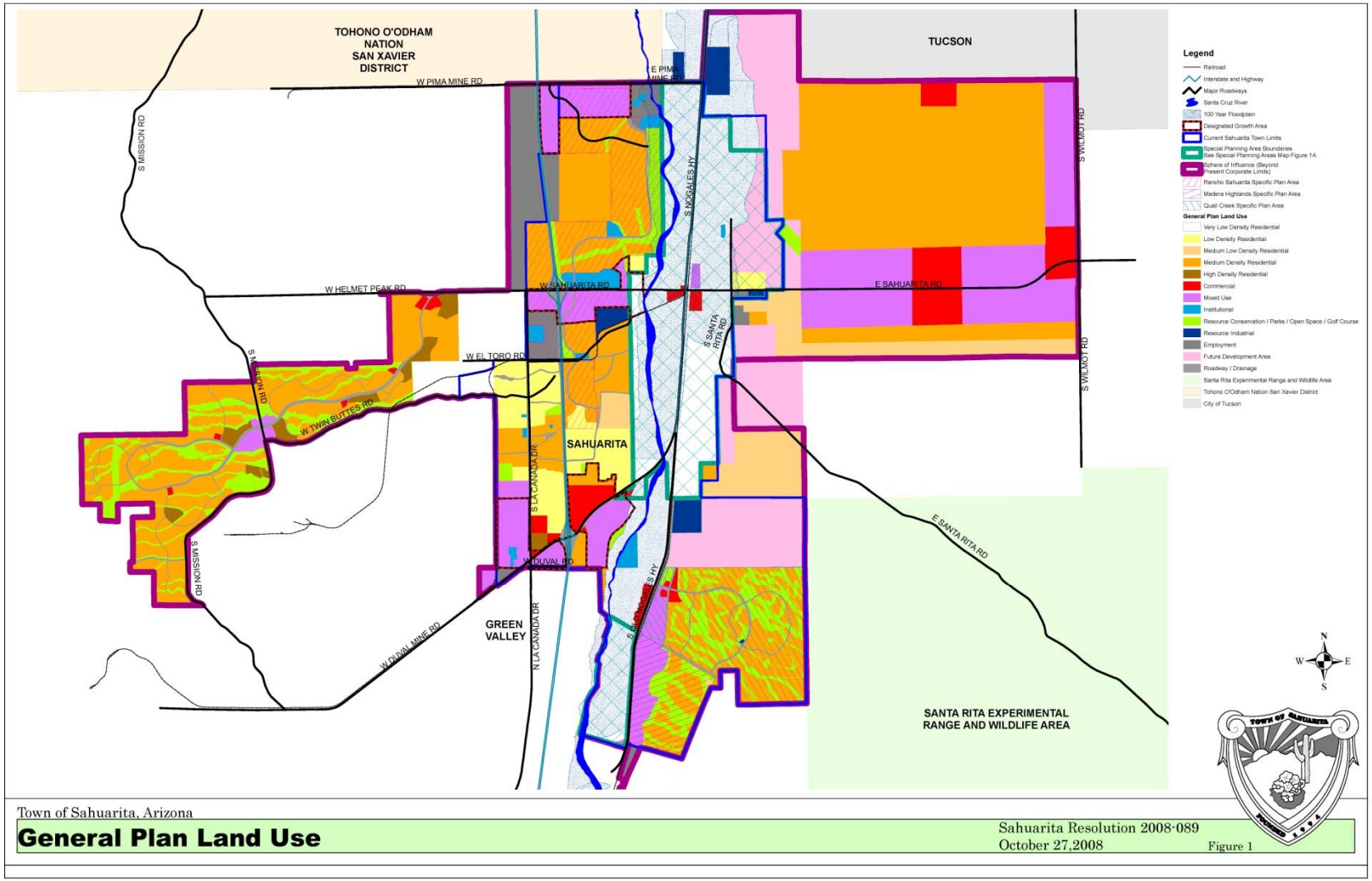
As illustrated in Table 4-2, in 2000 the population of Sahuarita was 3,242. With expanses of available land and residential growth, the population increased to 25,259 per the 2010 Census. These new population figures represent a significant growth not only to the community, but in the Sahuarita's population percentage within Pima County. By 2020, it is the Town of Sahuarita is expected to represent almost 5.6% of Pima County's population as compared with only 0.38% in 2000.

In addition to population, Sahuarita has also experienced economic growth yet a majority of full-time employees travel to the great Tucson area or are employed in service related facilities in Sahuarita and Green Valley. Agricultural production, in particular the pecan orchards owned by the Farmers Investment Company, and with a growth in area mining operations of Freeport McMoRan and ASARCO, still provided the basic Town employment. Other Town major private and public employers include Frye's, Safeway, Walmart, Ross Stores, American Home Furnishings, the Desert Diamond Casino – an operation of the Tohono O'odham Nation, and the Sahuarita School District and Town of Sahuarita. There is a small light industrial park on Duval Mine Road and business parks are in the evaluation/planning states. Carondelet has purchased land and will be announcing the specific types of ambulatory health care serviced that will become available in Sahuarita.

Ratified by Town residents on May 20, 2003, the Sahuarita General Plan reflects a community striving to preserve its rural character while realizing continual growth pressures. Over 50% of the land within the planning area is listed as Future Development Area. Although legally developable, demand is achieving the point to be high enough to warrant additional investment in these properties within the planning cycle of the General Plan. Growth area will be encouraged in the eastern portion of the Town and consist of a land use pattern emphasizing a mixture of uses. The future development plan stresses the importance of encouraging employments opportunities by designating 12.8% of the planning area's acreage to development of opportunities focusing on light industrial, office, research, and warehousing activities. These areas are expected to develop in the northern portion of the Interstate 19 corridor. Transitional to these usages are areas allocated for medical density resident and missed-use development providing flexibility in the design of concentrated areas allowing residents to live close to employment centers.

As of August 2011, the civilian labor force was 1,884 with an unemployment rate of 7.8%. In 2008, there were approximately $705.2 million of taxable sales in the town.[6]

[6] http://www.azcommerce.com/doclib/COMMUNE/sahuarita.pdf



Map 2-7: Town of Sahuarita General Plan Land Use

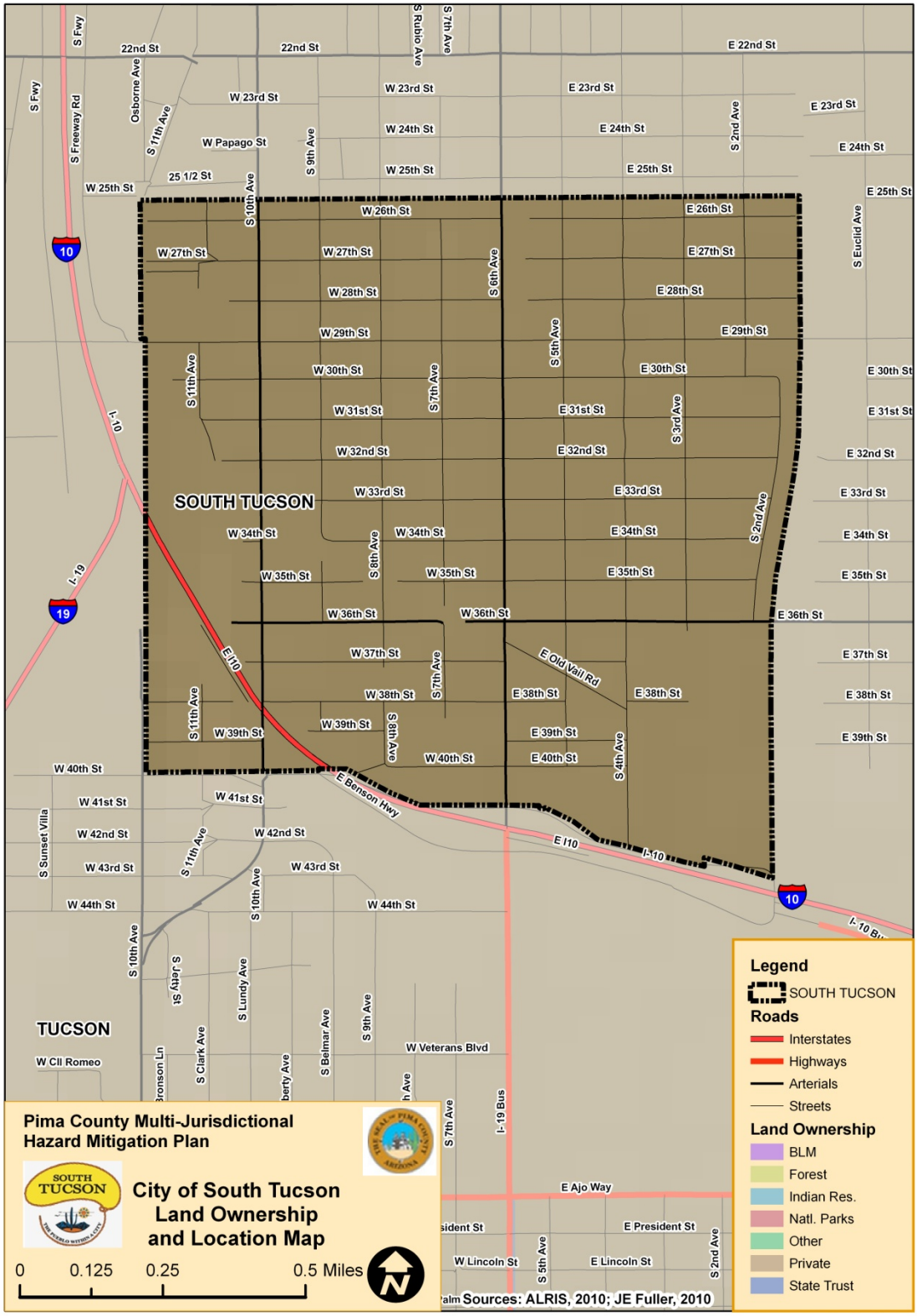
2.2.5 South Tucson

Surrounded by the City of Tucson, the City of South Tucson is a one square mile community just south of historical downtown Tucson nestled between the junction of Interstates 10 and 19. Rich in ethnic heritage, this small community services a population of which 83% are Mexican-American and 10% are Native American. Developed as a suburban community to Tucson, South Tucson enjoyed a colorful history after being incorporated in 1936, unincorporated in 1938, and reincorporated in 1940.

In 2000, the population of South Tucson was 5,490. Although relatively small growth (0.42% through 2020) is projected for the future, South Tucson will continue to provide an increasingly diminished percent of Pima County's overall resident population. This pattern is reflective of the strong growth throughout eastern Pima County and the City's inability to gain in available land mass. Similarly, South Tucson's small labor force is forecasted to parallel the Town's population growth by comprising a smaller share of the region's employment opportunities. The City of South Tucson updated their General Plan in 2002. Although not mandated to contain Growing Smarter elements due to their small size, this information was incorporated into the 2002 revision to provide consistency with other municipalities in the region.

As of August 2011, the civilian labor force was 2,616 with an unemployment rate of 22.6%. In 2008, there were approximately $86 million of taxable sales in the City.[7]

[7] http://www.azcommerce.com/doclib/COMMUNE/sahuarita.pdf



Map 2-8: City of South Tucson Land Ownership and Location

2.2.7 Tucson

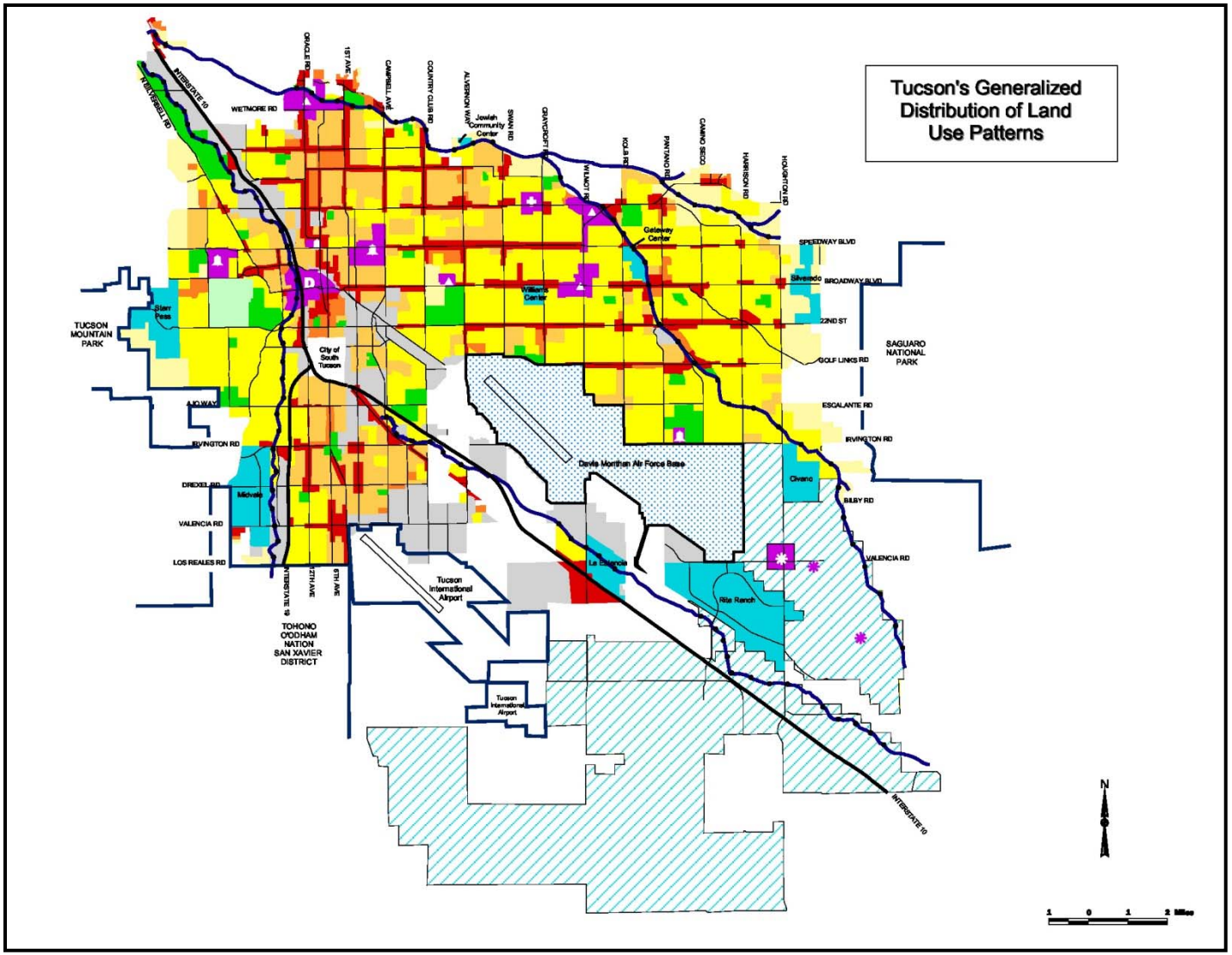
The City of Tucson, Arizona's second largest and oldest city, serves as the focal point for political, economic, and cultural activity for Pima County. Prior to the establishment of the first Spanish mission in 1700, San Xavier del Bac, and the arrival of the Spanish Conquistadors, various Native American tribes including the Pima, Hohokam and the Tohono O'odham inhabited the area presently occupied by the City of Tucson. Founded in 1775, Tucson began as a Spanish military garrison to protect settlers from Indian raids from nearby tribes. Receiving independence from Spanish colonial rule in 1821, governance of the area passed to the Republic of Mexico and remained part of the State of Sonora until 1854 when it became part of the United States with the Gadsden Purchase. Formally incorporated in 1877 with an area of 2 square miles, the City of Tucson presently includes 226 square miles and is the nation's thirtieth most populous City.

Fueled by the availability of cheap and abundant land, Tucson experienced rapid growth in the 1950s following World War II. Much of this new growth, however, occurred outside the city limits leading to a widespread lineal development pattern. Surrounded by unincorporated portions of Pima County, Tucson completely surrounds the City of South Tucson and is in close proximity to the smaller communities of Marana to the northwest, Oro Valley to the north, and Sahuarita to the south. A mayor and six City Council members representing various wards within the City govern Tucson. Operating under a charter form of government, the Mayor and City Council set policy to be carried out by an appointed City Manager and other city officials.

Known for its natural beauty, Tucson's natural environment is characteristic of the Sonoran Desert with diverse habitats and conditions ranging from low land deserts to the highlands of the Santa Catalina and Rincon Mountains. In addition to the rich biodiversity of the region, the close proximity of the Mexican border and the presence of the University of Arizona and the Davis-Monthan Air Force Base, which draw residents from throughout the United States as well as from other countries, influence the City's cultural diversity and tradition for cultural heritage preservation.

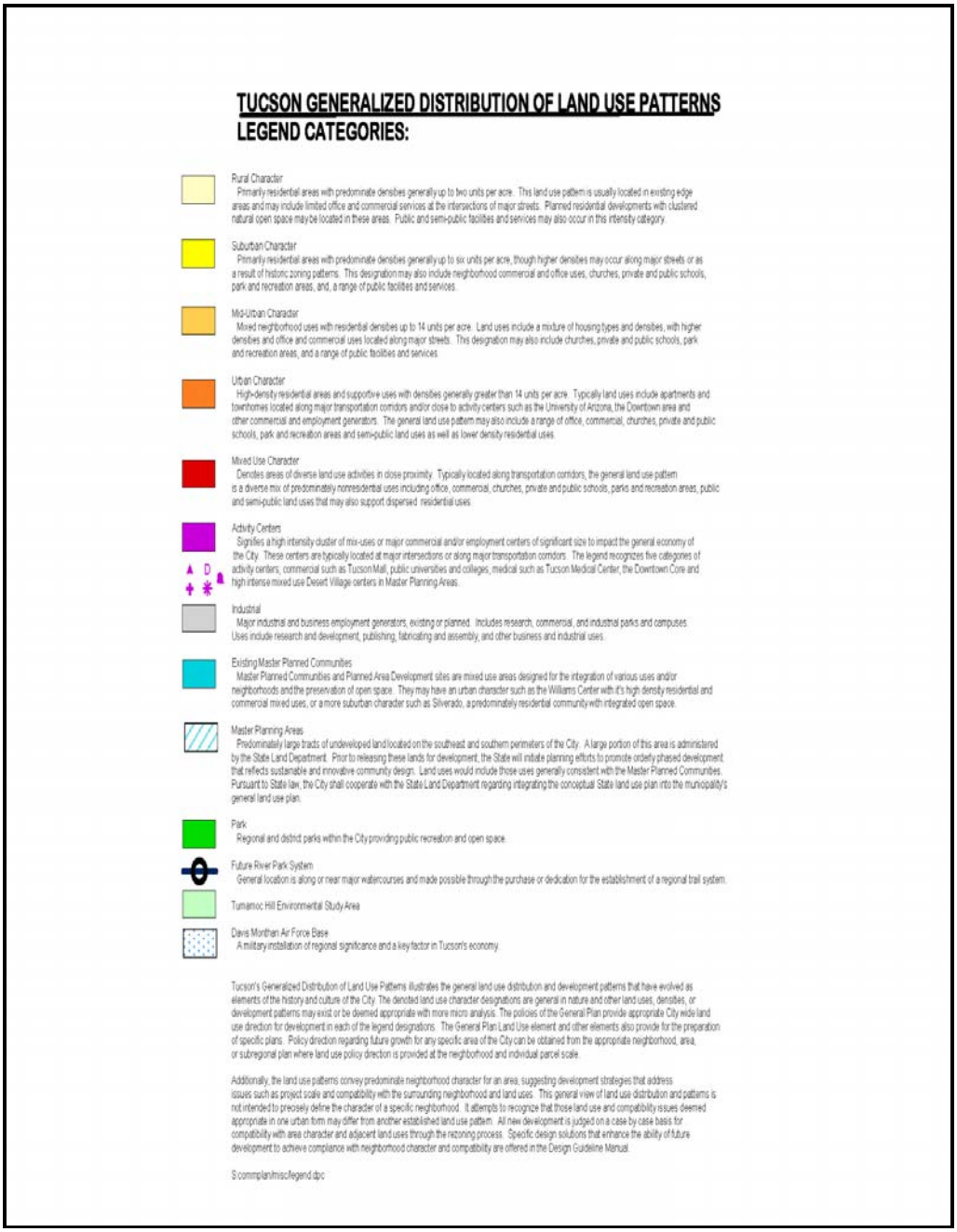
As depicted in Figure 4-12, Tucson's primary transportation corridors are Interstates 10 and 19, which provide accessibility to distant urban locations and a well-developed arterial network providing connectivity within the metropolitan area. Tucson International Airport, providing commercial air service, and Ryan Airfield, serving business and general aviation traffic, provide additional transportation service to Tucson.

The City of Tucson has experienced tremendous growth since its incorporation over 125 years ago. This growth has lead to a current population of just over 520,000 people, which represents 53% of the county according to the 2010 Census. Regardless of its role as the regional focal point, Tucson's relative position as the population center will slow in the future as other incorporated jurisdictions and unincorporated communities in the urban periphery absorb a larger share of the regional growth. As the regional economic engine, Tucson comprises 73.1% of the county's employment. However, by 2030 this figure is expected to drop to 60.9%. As of August 2011, the civilian labor force was 261,699 with an unemployment rate of 9.3%. In 2008, there were approximately $10.8 billion of taxable sales in the City.



Map 2-9: City of Tucson Generalized Distribution of Land Use Patterns 2001

Approved in December of 2001, Tucson's General Plan reflects a community that is responding to the diverse nature of its residents and natural character of the region. The plan anticipates that new growth will be accommodated primarily through infill development; higher density, mixed-use activity centers; and corridor planning to reduce the peripheral sprawl. Tucson is positioning itself to take advantage of its distinct natural setting by clearly separating urban uses from rural and natural resource-based areas. Economic development activity will be encouraged to locate transportation hubs along existing transportation corridors including Interstate 10, Interstate 19, the Southern Pacific Railroad, and airports. As an alternative to the lineal pattern of commercial development, small-scale neighborhood commercial centers will be focused at major street intersections with regional centers positioned in mixed-use activity centers.



TUCSON GENERALIZED DISTRIBUTION OF LAND USE PATTERNS
LEGEND CATEGORIES:

Rural Character
Primarily residential areas with predominate densities generally up to two units per acre. This land use pattern is usually located in existing edge areas and may include limited office and commercial services at the intersections of major streets. Planned residential developments with clustered natural open space may be located in these areas. Public and semi-public facilities and services may also occur in this intensity category.

Suburban Character
Primarily residential areas with predominate densities generally up to six units per acre, though higher densities may occur along major streets or as a result of historic zoning patterns. This designation may also include neighborhood commercial and office uses, churches, private and public schools, park and recreation areas, and, a range of public facilities and services.

Mid-Urban Character
Mixed neighborhood uses with residential densities up to 14 units per acre. Land uses include a mixture of housing types and densities, with higher densities and office and commercial uses located along major streets. This designation may also include churches, private and public schools, park and recreation areas, and a range of public facilities and services.

Urban Character
High-density residential areas and supportive uses with densities generally greater than 14 units per acre. Typically land uses include apartments and townhomes located along major transportation corridors and/or close to activity centers such as the University of Arizona, the Downtown area and other commercial and employment generators. The general land use pattern may also include a range of office, commercial, churches, private and public schools, park and recreation areas and semi-public land uses as well as lower density residential uses.

Mixed Use Character
Denotes areas of diverse land use activities in close proximity. Typically located along transportation corridors, the general land use pattern is a diverse mix of predominately nonresidential uses including office, commercial, churches, private and public schools, parks and recreation areas, public and semi-public land uses that may also support dispersed residential uses.

Activity Centers
Signifies a high intensity cluster of mix-uses or major commercial and/or employment centers of significant size to impact the general economy of the City. These centers are typically located at major intersections or along major transportation corridors. The legend recognizes five categories of activity centers; commercial such as Tucson Mall, public universities and colleges, medical such as Tucson Medical Center, the Downtown Core and high intense mixed use Desert Village centers in Master Planning Areas.

Industrial
Major industrial and business employment generators, existing or planned. Includes research, commercial, and industrial parks and campuses. Uses include research and development, publishing, fabricating and assembly, and other business and industrial uses.

Existing Master Planned Communities
Master Planned Communities and Planned Area Development sites are mixed use areas designed for the integration of various uses and/or neighborhoods and the preservation of open space. They may have an urban character such as the Williams Center with it's high density residential and commercial mixed uses, or a more suburban character such as Silverado, a predominately residential community with integrated open space.

Master Planning Areas
Predominately large tracts of undeveloped land located on the southeast and southern perimeters of the City. A large portion of this area is administered by the State Land Department. Prior to releasing these lands for development, the State will initiate planning efforts to promote orderly phased development that reflects sustainable and innovative community design. Land uses would include those uses generally consistent with the Master Planned Communities. Pursuant to State law, the City shall cooperate with the State Land Department regarding integrating the conceptual State land use plan into the municipality's general land use plan.

Park
Regional and district parks within the City providing public recreation and open space.

Future River Park System
General location is along or near major watercourses and made possible through the purchase or dedication for the establishment of a regional trail system.

Tumamoc Hill Environmental Study Area

Davis Monthan Air Force Base
A military installation of regional significance and a key factor in Tucson's economy.

Tucson's Generalized Distribution of Land Use Patterns illustrates the general land use distribution and development patterns that have evolved as elements of the history and culture of the City. The denoted land use character designations are general in nature and other land uses, densities, or development patterns may exist or be deemed appropriate with more micro analysis. The policies of the General Plan provide appropriate City wide land use direction for development in each of the legend designations. The General Plan Land Use element and other elements also provide for the preparation of specific plans. Policy direction regarding future growth for any specific area of the City can be obtained from the appropriate neighborhood, area, or subregional plan where land use policy direction is provided at the neighborhood and individual parcel scale.

Additionally, the land use patterns convey predominate neighborhood character for an area, suggesting development strategies that address issues such as project scale and compatibility with the surrounding neighborhood and land uses. This general view of land use distribution and patterns is not intended to precisely define the character of a specific neighborhood. It attempts to recognize that those land use and compatibility issues deemed appropriate in one urban form may differ from another established land use pattern. All new development is judged on a case by case basis for compatibility with area character and adjacent land uses through the rezoning process. Specific design solutions that enhance the ability of future development to achieve compliance with neighborhood character and compatibility are offered in the Design Guideline Manual.

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City of Tucson Generalized Distribution of Land Use Patterns-Legend

SECTION 3: PLANNING PROCESS

3.1 Planning Process

A total of four multi-jurisdictional planning team meetings were conducted over the period of February through May 2011, beginning with the first meeting on February 3, 2011. Two separate tribal planning meeting were also conducted with the Pascua Yaqui Tribe officials on April 12 and May 18, 2011. Throughout that period of time and for several months afterward, work required to collect, process, and document updated data and make changes to the plan was performed, culminating in a draft of the Plan. Details regarding key contact information and promulgation authorities, the planning team selection, participation, and activities, and public involvement are discussed in the following sections.

3.2 Planning Team and Activities

The role of the Planning Team was to work on the coordination, research, and planning element activities to update the 2007 Plan. Attendance by each participating jurisdiction was required for every Planning Team meeting, as the meetings were structured to progress step-by-step through the planning process. Steps and procedures for updating the 2007 Plan were presented and discussed at each Planning Team meeting, and assignments were given as necessary. Each meeting built on information discussed and assignments given at the previous meeting. The Planning Team was tasked with:

- Conveying information and assignments to the Local Planning Team
- Ensuring all requested assignments were completed fully and returned on a timely basis.
- Arranging for review and official adoption of the Plan.

The function and role of the Local Planning Team was to:

- Provide support and data
- Assist the Planning Team representative with assignments
- Make planning decisions regarding Plan components
- Review the Plan draft documents

At the beginning of this planning process, the Pima County Office of Emergency Management and Homeland Security (PCOEM) organized and identified members for the Planning Team by initiating contact with, and extending invitations to, all incorporated communities and Indian tribes within the county limits. The participating members of the Planning Team are summarized in Table 3-2. Returning planning team members are highlighted.

Table 3-1: Planning Team

Name	Jurisdiction / Organization	Planning Team Role
Char Ackerman Emergency Planner	Oro Valley Police Dept	Jurisdictional Point of Contact Lead coordinator for LPT Planning Team participant
Charles Barclay Superintendent	Dept of Transportation / Tucson District	Planning Team participant
Robert Bereiter Emergency Planner	Marana Police Dept	Planning Team participant Local Planning Team resource
Keith Brann Town Engineer	Marana Development - Engineering	Planning Team participant Local Planning Team resource
Lindy Brigham Executive Director	Southern AZ Buffelgrass Coordination Center /	Planning Team participant Local Planning Team resource
Bret Canale GIS DB Analyst	Marana GIS	Planning Team participant Local Planning Team resource
Anna Casadei Senior Planner	Sahuarita Planning & Zoning Dept	Planning Team participant Local Planning Team resource

Table 3-1: Planning Team

Name	Jurisdiction / Organization	Planning Team Role
Paul Casertano Operations & Safety Lead	Pima Association of Governments / Planning	Planning Team participant Local Planning Team resource
Dan Contorno CFO	Marana Unified School District	Planning Team participant
Dane Crouse Battalion Chief	Drexel Heights Fire District / Operations	Planning Team participant Local Planning Team resource
Brian Delfs Fire Chief	Avra Valley Fire District / Fire Dept	Planning Team participant Local Planning Team resource
Andy D'Entremont Planner	Pima Co Office of Emergency Management	Planning Team participant Local Planning Team resource
Jane Fairall Deputy Town Attorney	Marana Legal	Planning Team participant Local Planning Team resource
Jordan Feld Director	Tucson Airport Authority / Planning Dept	Planning Team participant Local Planning Team resource
Griselda Moya Flores Administrative Support	Pima Co Office of Emergency Management & Homeland Security	Planning Team participant Local Planning Team resource
Jeff Guthrie Operations Manager	Pima Co Office of Emergency Management & Homeland Security	Planning Team Primary Point of Contact Jurisdictional Point of Contact Lead coordinator for LPT Planning Team participant
Barb Harris Emergency Planner	Tucson Police Dept - Office of Emergency Management	Jurisdictional Point of Contact Joint coordinator for LPT Planning Team participant
Thomas Helfrich Manager	Pima Co Flood Control District	Planning Team participant Local Planning Team resource
Steven Johnson Sergeant/Emergency Planner	Marana Police Department	Jurisdictional Point of Contact Lead coordinator for LPT Planning Team participant
Paul Keesler Permitting Manager	Oro Valley Development Services	Planning Team participant Local Planning Team resource
Jim Kress Captain	City of Tucson / Fire Dept - EM / HS	Planning Team participant Local Planning Team resource
Brian Lauber District Forester	State Land Dept / State Forestry Division - Tucson District	Planning Team participant Local Planning Team resource
Rafael Leon Program Representative	Tucson Airport Authority / Sound Insulation	Planning Team participant Local Planning Team resource
Michael Losada Corporal	Tucson Airport Authority / Police Department	Planning Team participant Local Planning Team resource
Andre Matus Fire Chief	Pascua Yaqui Tribe / Pascua Pueblo Fire Department	Jurisdictional Point of Contact Lead coordinator for LPT Planning Team participant
Janet McLay Emergency Management Coordinator	City of Tucson / Office of Emergency Management	Jurisdictional Point of Contact Joint coordinator for LPT Planning Team participant
Mark Moore Design Reviewer	Town of Oro Valley / Water Utility - Engineering	Planning Team participant Local Planning Team resource
Lee Muscarella Battalion Chief	Golder Ranch Fire District / Suppression	Planning Team participant Local Planning Team resource
Jennifer Pegnato Sergeant	Tucson / Office of Emergency Management & Homeland Security / Police Dept	Planning Team participant Local Planning Team resource

Table 3-1: Planning Team

Name	Jurisdiction / Organization	Planning Team Role
Ed Pope Planner	Sahuarita Emergency Response	Jurisdictional Point of Contact Lead coordinator for LPT Planning Team participant
Jose Rodriguez Manager	Oro Valley DIS - Engineering	Planning Team participant Local Planning Team resource
Lisa Romero Administrative Support	Pima Co Office of Emergency Management & Homeland Security	Planning Team participant Local Planning Team resource
Jim Rosovich Contracting Officer	Pascua Yaqui Tribe Contracting Procurement	Planning Team participant Local Planning Team resource
Jim Schneden Sergeant	Tucson Police Dept - Homeland Security	Planning Team participant Local Planning Team resource
Lisa Shafer Planning Director	Marana Planning	Planning Team participant Local Planning Team resource
Nicolas Siemsen Program Coordinator	Pima Co Office of Emergency Management & Homeland Security	Planning Team participant Former Jurisdictional Point of Contact
James Stoltenberg Deputy Chief	Rural/Metro Fire District / Fire Dept	Planning Team participant Local Planning Team resource
Liz Temple Compliance Officer	Pima Co Office of Emergency Management & Homeland Security	Management level support for planning effort, Mitigation strategy development
T. Vanhook Director	Town of Marana / Community Development	Planning Team participant Local Planning Team resource
Henry Vega Director	South Tucson Public Works	Jurisdictional Point of Contact Lead coordinator for LPT Planning Team participant
Jim Vogelsberg Administrator	Tucson Planning & Development	Planning Team participant Local Planning Team resource
John Wisner Program Coordinator	Pima Co Office of Emergency Management & Homeland Security	Planning Team participant Local Planning Team resource
Susan Wood Planning Manager	AZ Division of Emergency Management	Management level support for planning effort, Mitigation strategy development

The Planning Team met for the first time on February 3, 2011 to begin the planning process. Three more meetings were convened on about a monthly basis to step through the plan review and update process. Planning Team members used copies of the 2007 Plan for review and reference. Following each Planning Team meeting, the Point of Contact for each jurisdiction would convene meetings with the Local Planning Team as needed to work through the assignments. Two tribal planning meeting meetings were convened with officials from the Pascua Yaqui Tribe to review and update the tribal plan elements.

An integral part of the planning process included coordination with agencies and organizations within and outside of the participating jurisdiction's governance to obtain information and data for inclusion into the Plan. Information and data used in this Plan may have been developed by agencies or organizations other than the participating jurisdictions. The Planning Team members are usually the individuals reaching out to those others to obtain input, data/information, expertise or direction for use in this Plan. Others involved or contributing to this Plan are listed below according to the jurisdiction that utilized them as a resource:

Table 3-2: Local Planning Resources

Name Title	Agency/Dept/Division	Jurisdiction	Role/Contribution

In addition to the adopting jurisdictions listed in Section 1.2, several agencies and organizations that operate within or have jurisdiction over small and large areas of Pima County were invited to participate in the planning process. Following the first Planning Team meeting, invitations were extended to several entities via both email and letter, to provide an opportunity for participation in the planning process. Copies of the various email and letter invitations are provided in Appendix B. The following is a partial list of the various agencies/organizations invited:

- Arizona Department of Transportation
- Arizona Division of Emergency Management
- Arizona State Land Department
- Avra Valley Fire District
- Drexel Heights Fire District
- Golder Ranch Fired District
- Marana School District
- Pima Association of Governments
- Pima County Department of Environmental Quality
- Pima County Department of Transportation
- Pima County Sheriff's Office
- Pima County Wastewater Management
- Pima Regional Flood Control District
- Tucson Electric Power Company
- Tucson Unified School District
- University of Arizona
- Raytheon Corporation
- Rural/Metro Fire District
- Southern Arizona Buffelgrass Committee
- Southwest Gas
- Tucson Airport Authority

An integral part of the planning process included coordination with agencies and organizations outside of the participating jurisdiction's governance to obtain information and data for inclusion into the Plan or to provide more public exposure to the planning process. Much of the information and data that is used in the risk assessment is developed by agencies or organizations other than the participating jurisdictions. In some cases, the jurisdictions may be members of a larger organization that has jointly conducted a study or planning effort like the development of a community wildfire protection plan or participation in an area association of governments. Examples of those data sets include FEMA floodplain mapping, the community wildfire protection plans, severe weather statistics and incidents, and the Pima Association of Governments. Jurisdictions needing these data sets obtained them by requesting them directly from the host agency or organization, downloading information posted to website locations, or engaging consultants.

3.3 Public and Stakeholder Involvement

Past Activities

Pre-draft public involvement and input to the planning process was encouraged cooperatively among all of the participating jurisdictions using the following strategies:

Pima County

- Post a notice to the county website.
- Issue a press release similar to what was done for the 2007 Plan.
- Coordinate the provision of links to the county's website with each jurisdiction.

Marana

- Post a notice to town's website with a link to the county's.
- Publish an article/public notice in their local newspaper.

Oro Valley

- Post a notice to town's website with a link to the county's.

Pascua Yaqui Tribe

- Post a notice to town's website with a link to the county's.
- Publish an article/public notice in their local newspaper.
- Provide an announcement on the local radio station

Sahuarita

- Post a notice to town's website with a link to the county's.
- Publish an article/public notice in their local newspaper.
- Presentation/announcement at the Chamber of Commerce "For Our Cities" event.

Tucson

- Post a notice to city's website with a link to the county's.

South Tucson

-

Contact information provided on the websites and notices will at a minimum include a name, email, and phone information for the primary jurisdictional contact plus a link to the Pima County Office of Emergency Management and Homeland Security. Any comments will be addressed as appropriate and routed to the Planning Team Primary Point of Contact.

To date, there have been no questions, concerns, or responses received from the first round of notices from the general public.

The post-draft public involvement will include a second round of newspaper announcements and updating of the websites, to include specific instructions for obtaining or viewing a draft of the plan.

All of the notices, postings, and articles encouraged review and comment of the draft Plan by the public. Interested citizens were also encouraged to participate in the local community adoption process which, depending upon the jurisdiction, may have included a public meeting and a formal public hearing. Copies of the pre- and post-draft public notices, web pages, and newspaper notices are provided in the Appendix.

Future Activities

Pima County

-

Town of Marana

-

Town of Oro Valley

-

Pascua Yaqui Tribe

-

Town of Sahuarita

-

City of Tucson

-

City of South Tucson

-

Tribal Definition of "Public"

The Pascua Yaqui Tribe has formulated the following statement to define "public" for the purposes of this planning effort to satisfy the Tribal Planning requirements:

"All residents of the Pascua Yaqui Reservation, as its boundaries may be revised from time to time."

3.4 Reference Documents and Resources

Over the course of the update planning process, numerous other plans, studies, reports, and technical information were obtained and reviewed for incorporation or reference purposes. The majority of sources referenced and researched pertain to the risk assessment and the capabilities assessment. To a lesser extent, the community descriptions and mitigation strategy also included some document or technical information research. Table 3-5 provides a reference listing of the primary documents and technical resources reviewed and used in the Plan. Detailed bibliographic references for the risk assessment are provided at the end of each hazard risk profile in Section 5.3. Other bibliographic references are provided as footnotes.

Table 3-3: Resource documents and reviewed and incorporated in this plan

Resource	Description of Reference and Its Use
AZ Department of Commerce	Reference for demographic and economic data for the county. Used for community descriptions
AZ Division of Emergency Management	Resource for state and federal disaster declaration information for Arizona. Also a resource for hazard mitigation planning guidance and documents.
AZ Department of Water Resources	Resource for data on drought conditions and statewide drought management (AzGDTF), and dam safety data. Used in risk assessment.
AZ Geological Survey	Resource for earthquake, fissure, landslide/mudslide, subsidence, and other geological hazards. Used in the risk assessment.
AZ Model Local Hazard Mitigation Plan	Guidance document for preparing and formatting hazard mitigation plans for Arizona.
AZ State Land Department	Source for statewide GIS coverages (ALRIS) and statewide wildfire hazard profile information (Division of Forestry). Used in the risk assessment.
AZ Wildland Urban Interface Assessment (2004)	Source of wildfire hazard profile data and urban interface at risk communities. Used in the risk assessment.
AZ Workforce Informer	Source for employment statistics in Arizona.
Bureau Net (2010)	Source for NFIP statistics for Arizona.
Census Bureau	Source for 2010 Census demographics
Federal Emergency Management Agency	Guidance (How-To series) for floodplain and flooding related NFIP data (mapping, repetitive loss, NFIP statistics), and historic hazard incidents. Used in the risk assessment and mitigation strategy.
HAZUS-MH	Based data sets within the program were used in the vulnerability analysis.
National Climatic Data Center	Online resource for weather related data and historic hazard event data. Used in the risk assessment.
National Weather Service	Source for hazard information, data sets, and historic event records. Used in the risk assessment.
National Wildfire Coordination Group (2010)	Source for historic wildfire hazard information. Used in the risk assessment.
Pima Association of Governments	Source for demographic and 2010 Census block level data.
Pima Co Hazard Mitigation Plan (2007)	FEMA approved hazard mitigation plan that is the subject of the plan update process. See Section 2.4 for further discussion
Office of the State Climatologist for AZ	Reference for weather characteristics for the county. Used for community description.

Table 3-3: Resource documents and reviewed and incorporated in this plan

Resource	Description of Reference and Its Use
Standard on Disaster/ Emergency Management and Business Continuity Programs (2000)	Used to establish the classification and definitions for the asset inventory. Used in the risk assessment.
State of Arizona Hazard Mitigation Plan (2010)	The state plan was used a source of hazard information and the state identified hazards were used as a starting point in the development of the risk assessment.
USACE Flood Damage Report (1978)	Source of historic flood damages for 1978 flood. Used in the risk assessment.
USACE Flood Damage Report (1994)	Source of historic flood damages for 1993 flood. Used in the risk assessment.
US Forest Service	Source for local wildfire data. Used in the risk assessment.
US Geological Survey	Source for geological hazard data and incident data. Used in the risk assessment.
Western Regional Climate Center	Online resource for climate data used in climate discussion of Section 4
World Wildlife Fund (2010)	Terrestrial ecoregions database used in the general county description.

SECTION 4: RISK ASSESSMENT

4.1 Section Changes

- The Environmental Rating and Consequence/Impacts sections have been removed as they were determined not to be beneficial or worth the effort to maintain them.

One of the key elements to the hazard mitigation planning process is the risk assessment. In performing a risk assessment, a community determines "what" can occur, "when" (how often) it is likely to occur, and "how bad" the effects could be which is generally categorized into the following measures:

Hazard Identification and Screening

Hazard Profiling

Assessing Vulnerability to Hazards

The risk assessment for Pima County and participating jurisdictions was performed using a county-wide, multi-jurisdictional perspective, with much of the information gathering and development being accomplished by the Planning Team. This integrated approach was employed because many hazard events are likely to affect numerous jurisdictions within the County, and are not often relegated to a single jurisdictional boundary. The vulnerability analysis was performed in a way such that the results reflect vulnerability at an individual jurisdictional level, and at a countywide level.

4.2 Hazard Identification

Hazard identification is the process of answering the question; *"What hazards can and do occur in my community or jurisdiction?"* For this Plan, the list of hazards identified in the 2006 Plan were reviewed by the Planning Team with the goal of refining the list to reflect the hazards that pose the greatest risk to the jurisdictions represented by this Plan. The Planning Team also compared and contrasted the 2006 Plan list to the comprehensive hazard list summarized in the 2010 State Plan[8] to ensure compatibility with the State Plan. Table 5-1 summarizes the 2006 Plan and 2010 State Plan hazard lists.

Table 4-1: Hazard identification lists

2007 Hazards for Plan	2016 Hazards for Plan
• Dam Failure • Disease • Drought • Extreme Heat • Flooding • Hail • HAZMAT • Lightning • Subsidence • Thunderstorm • Tornado • Tropical Cyclone • Wildfire • Winter Storm	• Dam Failure • Drought • Earthquake • Extreme Heat • Fissure • Flooding/Flash Flooding • Landslide / Mudslide • Levee Failure • Severe Wind • Subsidence • Wildfire • Winter Storms

The review included an initial screening process to evaluate each of the listed hazards based on the following considerations:

[8] ADEM, 2007, *State of Arizona Multi-Hazard Mitigation Plan*

- Experiential knowledge on behalf of the Planning Team with regard to the relative risk associated with the hazard
- Documented historic context for damages and losses associated with past events (especially events that have occurred during the last plan cycle)
- The ability/desire of Planning Team to develop effective mitigation for the hazard under current DMA 2000 criteria
- Compatibility with the state hazard mitigation plan hazards
- Duplication of effects attributed to each hazard

The table below summarizes federal and state disaster declarations that included Pima County. When reviewing the table, the following should be noted, if a hazard is not listed, that means there were no events reported for that hazard that fit the criteria above.

Table 4-2: Disaster Cost for Declared Events That Included Pima County –

Hazard Categories	Arizona Declared Events That Included Pima County January 1966 to August 2010		
	No. of Events	Total Expenditures	
		State	Federal
Disease	7	$ 1,738,895	$ -
Drought	3	$ 226,440	$ -
Flooding / Flash Flooding	12	$ 42,334,412	$ 333,683,342
Flood / Severe Wind	1	$ 16,158	$ 10,879,002
Hazardous Materials Incident	3	$ 1,611,337	$ -
Severe Wind	1	$ 14,238	$ -
Wildfire	17	$ 6,369,936	$ 5,907,407

Notes: Damage Costs are reported as is and no attempt has been made to adjust costs to current dollar values.
- Only a portion of the reported expenditures were spent in the subject county.

Source: DEMA, October 2010

The Planning Team has selected the following list of hazards for profiling and updating based on the above explanations and screening process. Revised and updated definitions for each hazard are provided in Section 5.3 and in Section 8.2:

- **Disease**
- **Drought**
- **Earthquake**
- **Extreme Temperature**
- **Flooding/Flash Flooding**
- **HAZMAT**
- **Levee Failure**
- **Severe Wind**
- **Subsidence**
- **Wildfire**
- **Winter Storms**

4.3 Vulnerability Analysis Methodology

General

The following sections summarize the methodologies used to perform the vulnerability analysis portion of the risk assessment. For this Plan, the entire vulnerability analysis was either revised or updated to reflect new hazard categories, the availability of new data, or differing loss estimation methodology.

For the purposes of this vulnerability analysis, hazard profile maps were developed for Earthquake, Flooding/Flash Flooding, Fissure, Levee Failure, Subsidence, Wildfire and Winter Storm to map the geographic variability of the probability and magnitude of exposure risk as estimated by the Planning Team. Hazard profile categories of HIGH, MEDIUM, and/or LOW were used (except for Earthquake and Winter Storm) and were subjectively assigned based on the factors discussed in the Probability and Magnitude sections below. Within the context of the county limits, the other hazards do not exhibit significant geographic variability and will not be categorized as such.

Unless otherwise specified in this Plan, the general cutoff date for new hazard profile data and jurisdictional corporate limits is the end of May 2011.

Calculated Priority Risk Index (CPRI) Evaluation

The first step in the vulnerability analysis (VA) is to assess the perceived overall risk for each of the plan hazards using the Calculated Priority Risk Index[9] (CPRI). The CPRI value is obtained by assigning varying degrees of risk to four categories for each hazard, and then calculating an index value based on a weighting scheme. Table 5-5 summarizes the CPRI risk categories and provides guidance regarding the assignment of values and weighting factors for each category.

As an example, assume that the project team is assessing the hazard of flooding, and has decided that the following assignments best describe the flooding hazard for their community:

- Probability = Likely
- Magnitude/Severity = Critical
- Warning Time = 12 to 24 hours
- Duration = Less than 6 hours

The CPRI for the flooding hazard would then be:

CPRI = [(3*0.45) + (3*0.30) + (2*0.15) + (1*0.10)]

CPRI = 2.65

Asset Inventory

A detailed asset inventory was performed for the 2007 Plan to establish a fairly accurate baseline data-set for assessing the vulnerability of each jurisdiction's assets to the hazards previously identified. The asset inventory from the 2007 Plan was updated to reflect the current critical and non-critical facilities potentially exposed to hazards. Details of the update are discussed later in this section.

The asset inventory is generally tabularized into ***critical*** and ***non-critical*** categories. ***Critical facilities and infrastructure*** are systems, structures and infrastructure within a community whose incapacity or destruction would *have a debilitating impact on the defense or economic security of that community* and/or *significantly hinder a community's ability to recover following a disaster*.

The following criteria has been adopted to define critical facilities and infrastructure:

1. **Communications Infrastructure:** Telephone, cell phone, data services, radio towers, and internet communications, which have become essential to continuity of business, industry, government, and military operations.
2. **Electrical Power Systems:** Generation stations and transmission and distribution networks that create and supply electricity to end-users.
3. **Gas and Oil Facilities:** Production and holding facilities for natural gas, crude and refined petroleum, and petroleum-derived fuels, as well as the refining and processing facilities for these fuels.
4. **Banking and Finance Institutions:** Banks, financial service companies, payment systems, investment companies, and securities/commodities exchanges.
5. **Transportation Networks:** Highways, railroads, ports and inland waterways, pipelines, and airports and airways that facilitate the efficient movement of goods and people.
6. **Water Supply Systems:** Sources of water; reservoirs and holding facilities; aqueducts and other transport systems; filtration, cleaning, and treatment systems; pipelines; cooling systems; and other delivery mechanisms that provide for domestic and industrial applications, including systems for dealing with water runoff, wastewater, and firefighting.

[9] ADEM, 2003, *Arizona Model Local Hazard Mitigation Plan*, prepared by JE Fuller/ Hydrology & Geomorphology, Inc.

7. **Government Services:** Capabilities at the federal, state, and local levels of government required to meet the needs for essential services to the public.
8. **Emergency Services:** Medical, police, fire, and rescue systems.

Table 4-3: Calculated Priority Risk Index categories and risk levels

CPRI Category	Degree of Risk			Assigned Weighting Factor
	Level ID	Description	Index Value	
Probability	Unlikely	▪ Extremely rare with no documented history of occurrences or events. ▪ Annual probability of less than 0.001.	1	45%
	Possible	▪ Rare occurrences with at least one documented or anecdotal historic event. ▪ Annual probability that is between 0.01 and 0.001.	2	
	Likely	▪ Occasional occurrences with at least two or more documented historic events. ▪ Annual probability that is between 0.1 and 0.01.	3	
	Highly Likely	▪ Frequent events with a well documented history of occurrence. ▪ Annual probability that is greater than 0.1.	4	
Magnitude/ Severity	Negligible	▪ Negligible property damages (less than 5% of critical and non-critical facilities and infrastructure). ▪ Injuries or illnesses are treatable with first aid and there are no deaths. ▪ Negligible quality of life lost. ▪ Shut down of critical facilities for less than 24 hours.	1	30%
	Limited	▪ Slight property damages (greater than 5% and less than 25% of critical and non-critical facilities and infrastructure). ▪ Injuries or illnesses do not result in permanent disability and there are no deaths. ▪ Moderate quality of life lost. ▪ Shut down of critical facilities for more than 1 day and less than 1 week.	2	
	Critical	▪ Moderate property damages (greater than 25% and less than 50% of critical and non-critical facilities and infrastructure). ▪ Injuries or illnesses result in permanent disability and at least one death. ▪ Shut down of critical facilities for more than 1 week and less than 1 month.	3	
	Catastrophic	▪ Severe property damages (greater than 50% of critical and non-critical facilities and infrastructure). ▪ Injuries or illnesses result in permanent disability and multiple deaths. ▪ Shut down of critical facilities for more than 1 month.	4	
Warning Time	Less than 6 hours	Self explanatory.	4	15%
	6 to 12 hours	Self explanatory.	3	
	12 to 24 hours	Self explanatory.	2	
	More than 24 hours	Self explanatory.	1	
Duration	Less than 6 hours	Self explanatory.	1	10%
	Less than 24 hours	Self explanatory.	2	
	Less than one week	Self explanatory.	3	
	More than one week	Self explanatory.	4	

Other assets such as public libraries, schools, businesses, museums, parks, recreational facilities, historic buildings or sites, churches, residential and/or commercial subdivisions, apartment complexes, and so forth, are typically not classified as critical facilities and infrastructure unless they serve a secondary function to the community during a disaster emergency (e.g. - emergency housing or evacuation centers). New facilities were also added as appropriate and available.

The 2007 Plan used a combination of the Asset Inventory and HAZUS®-MH[10] data to represent the critical facilities for Pima County jurisdictions, however, those data sets were not available for use with this update. The Pima County Office of Emergency Management and Homeland Security coordinated with regional emergency planners from each jurisdiction to prepare a database of critical facilities and infrastructure. Each jurisdiction was given the responsibility for making the decisions regarding which and how many assets would be reported. Updates included changes to the geographic position, revision of asset names, updating replacement costs, etc.

It should be noted that the facility counts summarized in Table 5-6 do not represent a comprehensive inventory of all the category facilities that exist within the County. They do represent the facilities inventoried to date by each jurisdiction and are considered to be a work-in-progress that is to be expanded and augmented with each Plan cycle.

Table 4-4: Asset inventory structures as of May 2011

	Communications Infrastructure	Electrical Power Systems	Gas/Oil Facilities	Banking/Finance Institutions	Transportation Networks	Water Supply Systems	Government Services	Emergency Services	Educational [a]	Cultural [a]	Business [a]	Flood Control [a]	Residential [a]	Recreational [a]
County-Wide Totals	**1603**	**29**	**105**	**0**	**572**	**115**	**171**	**129**	**750**	**0**	**12**	**0**	**0**	**0**
Marana	142	5	14	(22) [b]	34	23	13	7	25	0	9	0	0	0
Oro Valley	29	1	0	0	6	64	4	9	19	0	0	0	0	0
Pascua Yaqui Tribe	4	0	1	0	1	0	1	5	1	0	3	0	0	0
Sahuarita	16	1	0	0	19	15	3	4	18	0	0	0	0	0
South Tucson	1	0	0	0	6	0	5	2	5	0	0	0	0	0
Tohono O'odham	31	0	4	0	57	3	0	2	11	0	0	0	0	0
Tucson	686	12	20	0	220	26	93	41	527	0	0	0	0	0
Unincorporated Pima	694	10	66	0	229	48	52	59	144	0	0	0	0	0

a – Assets listed under these categories have been determined to be critical per the definition of this Plan by the corresponding jurisdiction.
b – These were not included in asset inventory database but are reported here to acknowledge their existence and need for inclusion to the database at the next Plan update.

Loss Estimations

In the original 2007 Plan, losses were estimated by either quantitative or qualitative methods. Where applicable, quantitative methods employed the loss estimating algorithms coded into the HAZUS MH® program, or statistically based estimations using historic data. Where quantitative information or standardized software was lacking, a more qualitative evaluation was made on the basis of each hazard's characteristics.

Loss estimates for this Plan will be similar in scope and detail to the 2007 Plan, but will reflect current hazard map layers, an updated asset database, and the use of Census 2010 block level data for estimating the human and residential structure impacts wherever possible. HAZUS MH® currently includes data sets that are based on 2000 Census information. Upon review by the Planning Team, a decision was made to use more current 2010 Census Block data instead. The procedures for developing loss estimates are discussed below.

[10] U.S. Department of Homeland Security, Federal Emergency Management Agency, HAZUS®-MH.

Economic loss and human exposure estimates for each of the final hazards identified in Section 5.1 begins with an assessment of the potential exposure of critical infrastructure, human populations, and residential structures to those hazards. Estimates of critical assets identified by each jurisdiction (see Table 5-5) are accomplished by intersecting the asset inventory with the hazard profiles in Section 5.3. Human or population exposures are estimated by intersecting the same hazards with the 2010 Census Block data population statistics.

Additional exposure estimates for general residential buildings within the county is also made using the residential housing counts reported in the 2010 Census data. Replacement costs for the residential housing counts were estimated by geographical area within the County, using July 2011 mean home sales data published by Zillow® Real Estate.[11] All areas outside of the Census Places boundaries were assigned a county-wide mean. Combining the exposure results from the critical asset inventory and the 2010 Census database provides a fairly comprehensive depiction of the overall exposure of critical facilities, human population, and residential building stock and the two datasets are considered complementary and not redundant.

Economic losses to structures and facilities are estimated by multiplying the exposed facility replacement cost estimates by an assumed loss to exposure hazard ratio. The loss to exposure ratios used are summarized by hazard in Section 5.3. It is important to note the following when reviewing the loss estimate results:

- The loss to exposure ratios are subjective and the estimates are solely intended to provide an understanding of relative risk from the hazards and potential losses.
- Potential losses reported in this Plan represent an inherent assumption that the hazard occurs county-wide to magnitude shown on the hazard profile map. The results are intended to present a county-wide loss potential. Any single hazard event will likely only impact a portion of the county and the actual losses would be some fraction of those estimated herein.
- No attempt has been made at developing annualized loss estimates, unless otherwise noted in Section 5.3

It is also noted that uncertainties are inherent in any loss estimation methodology due to:

- Incomplete scientific knowledge concerning hazards and our ability to predict their effects on the built environment;
- Approximations and simplifications that are necessary for a comprehensive analysis; and,
- Lack of detailed data necessary to implement a viable statistical approach to loss estimations.

Several of the hazards profiled in this Plan will not include quantitative exposure and loss estimates. The vulnerability of people and assets associated with some hazards are nearly impossible to evaluate given the uncertainty associated with where these hazards will occur as well as the relatively limited focus and extent of damage. Instead, a qualitative review of vulnerability will be discussed to provide insight to the nature of losses that are associated with the hazard. For subsequent updates of this Plan, the data needed to evaluate these unpredictable hazards may become refined such that comprehensive vulnerability statements and thorough loss estimates can be made.

Development Trend Analysis

The 2007 Plan development trend analysis will require updating to reflect growth and changes in Pima County and jurisdiction boundaries over the last planning cycle. The updated analysis will focus on the potential risk associated with projected growth patterns and their intersection with the Plan identified hazards.

Pascua Yaqui Tribe Cultural/Sacred Sites

Like the assets listed above, cultural and sacred sites are of high priority to the Pascua Yaqui Tribe and special attention is needed when considering hazard mitigation of these areas. Because of their cultural importance, these sites require special attention and protection. The Tribe's practice is to not share the location of these sites and areas. For this reason these sites and areas will not be included in this Plan. The Pascua Yaqui Tribe will ensure within its internal planning efforts that these sites and areas are included in their mitigation activities.

[11] Zillow website at the following URL: http://www.zillow.com/local-info/AZ-Pima-County-home-value/r_281/

4.4 Hazard Risk Profiles

The following sections summarize the risk profiles for each of the Plan hazards identified in Section 5.1. For each hazard, the following elements are addressed to present the overall risk profile:

- **Description**
- **History**
- **Probability and Magnitude**
- **Vulnerability**
  - **CPRI Results**
  - **Loss Estimations**
  - **Development Trends**
- **Sources**
- **Profile Maps (if applicable)**

Much of the 2007 Plan data has been updated, incorporated and/or revised to reflect current conditions and Planning Team changes, as well as an overall plan format change. Historic discussions for each hazard are limited to state and count impacts, unless broader discussions are warranted. County-wide and jurisdiction specific profile maps are provided at the end of the section (if applicable).

4.4.1 Disease

Description

A disease is a pathological (unhealthy or ill) condition of a living organism or part of the organism that is characterized by an identifiable group of symptoms or signs. Disease can affect any living organism, including people, animals, and plants. Disease can both directly (through infection) and indirectly (through secondary impacts) affect people, animals, and plants. Some diseases can directly affect both people and animals by infecting both. The most hazardous disease threat is the occurrence of an epidemic, which is a disease that affects numerous people, animals, or plants at one time.

Of great concern for human, animal and plant health are infectious diseases caused by the entry and growth of microorganisms in another living organism. Some, but not all, infectious diseases are contagious, meaning they are communicable through direct or even indirect contact with an organism infected with the disease, something it has touched, or another medium (e.g., water, air). According to the Centers for Disease Control and Prevention (CDC), during the first half of the twentieth century, optimism grew as steady progress was made against infectious diseases in humans resulting from improved water quality, sanitation, antibiotics, and inoculations (CDC, October 1998). The incidences and severity of infectious diseases such as tuberculosis, typhoid fever, smallpox, polio, whooping cough, and diphtheria were all significantly reduced during this period. This optimism proved premature, however, for a variety of reasons, including the following: antibiotics began to lose their effectiveness against infectious disease (e.g., Staphylococcus aureus); new strains of influenza emerged in China and spread rapidly around the globe; sexually transmitted diseases surged; new diseases were identified in the U.S. and elsewhere (e.g., Legionnaires's disease, Lyme disease, toxic shock syndrome, and Ebola hemorrhagic fever); acquired immunodeficiency syndrome (AIDS) appeared; and tuberculosis (including drug-resistant strains) reemerged (CDC, October 1998).

In a 1992 report entitled *Emerging Infections: Microbial Threats to Health in the United States*, the Institute of Medicine (IOM) identified the growing links between U.S. and international health, and concluded that emerging infections are a major and growing threat to the U.S. An emerging infectious disease is one whose incidence in humans has increased during the previous decades or threatens to increase in the near future. Emerging infectious diseases are a product of modern demographic and environmental conditions, such as global travel, globalization and centralized processing of the food supply, population growth and increased urbanization. In response to the threat of emerging infectious diseases, the CDC launched a national effort to protect the US public in a plan entitled Addressing Emerging Infectious Disease Threats. Based on the CDC's plan, major improvements to the US health system have been implemented, including improvements in surveillance, applied research, public health infrastructure, and prevention of emerging infectious diseases (CDC, October 1998).

Despite these improvements, infectious diseases are the leading cause of death in humans worldwide and the third leading cause of death in humans in the U.S. (American Society for Microbiology, June 21, 1999). A recent follow-up report from the Institute of Medicine, entitled *Microbial Threats to Health: Emergence, Detection, and Response*, notes that the impact of infectious diseases on the U.S. has only grown in the last ten years and that public health and medical communities remain inadequately prepared. Further improvements are necessary to prevent, detect, and control emerging, as well as resurging, microbial threats to health. The danger posed by infectious diseases is compounded by other important trends: the continuing increase in antimicrobial resistance; the US' diminished capacity to recognize and respond to microbial threats; and the intentional use of biological agents to do harm (Institute of Medicine, 2003).

The CDC maintains a list of over 50 nationally notifiable diseases. A notifiable disease is one that, when diagnosed, health providers are required, usually by law, to report to State or local public health officials. Notifiable diseases are those of public interest by reason of their contagiousness, severity, or frequency. The long list includes such diseases as the following: AIDS; anthrax; botulism; cholera; diphtheria; encephalitis; gonorrhea; Hantavirus pulmonary syndrome; hepatitis (A, B, C); HIV (pediatric); Legionellosis; Lyme disease; malaria; measles; mumps; plague; polio (paralytic); rabies (animal and human); Rocky Mountain spotted fever; rubella (also congenital); Salmonellosis; SARS; Streptococcal disease (Group A); Streptococcal toxic-shock syndrome; Streptococcus pneumoniae (drug resistant); syphilis (also congenital); tetanus; Toxic-shock syndrome; Trichinosis, tuberculosis, Typhoid fever; and Yellow fever (Centers for Disease Control and Prevention, May 2, 2003). In addition to diseases found only in humans, there is also significant concern about diseases that affect both humans and animals, known as zoonotic diseases. There are approximately 40 zoonotic diseases, including the following: rabies; tuberculosis and brucellosis; trichinosis; ringworm; giardiasis; and Lyme disease (Will, April 2002). Pima County is also very active in fighting the spread of the West Nile Virus through the control of mosquitoes.

In Pima County, the Pima County Health Department seeks to prevent infectious diseases from entering the county and control those that are endemic or have already entered. Of particular concern to the County Health Department are new pandemic diseases, such as SARS, new strains of HIV, new influenza strains such as the most recent H1N1 threat, botulism, and bio-terrorism pathogens such as anthrax, smallpox, or chemical attacks of sarin or VX gas. As a component of the Pima County Health Department, the Disease Control division seeks to reduce the incidence of disease morbidity and mortality in Pima County through the identification of community health problems, compilation of health statistics, and development of appropriate intervention programs. Special attention is paid to epidemiology, HIV/AIDS, sexually transmitted diseases, in addition to preventive programs such as immunizations and well women services.

Diseases affecting animals and plants, particularly livestock and agricultural products, are also of major concern, as they can affect the supply and quality of human food supplies, potential economic consequences, and impact foreign trade. According to the National Animal Health Emergency Management System (NAHEMS), an animal health emergency is defined as the appearance of disease with the potential for sudden negative impacts through direct effects on productivity, real or perceived risks to public health, or real or perceived risks to foreign countries importing from the U.S. (Lautner, April 18, 2002).

A division of the United States Department of Agriculture (USDA), the Animal and Plant Health Inspection Service (APHIS) is responsible for protecting and promoting U.S. agricultural health, administering the Animal Welfare Act, and carrying out wildlife damage management activities. Major programs within APHIS relating to disease are Veterinary Services (VS) and Plant Protection and Quarantine (PPQ). Veterinary Services protects and improves the health, quality, and marketability of animals, animal products and veterinary biologics by (i) preventing, controlling and/or eliminating animal diseases, and (ii) monitoring and promoting animal health and productivity. Among other activities, Veterinary Services conducts surveillance on national animal diseases, foreign animal diseases, emerging animal diseases, and invasive plant species. Most of Veterinary Services efforts are targeted at diseases on the Organization Internationale des Epizooties (OIE) “A” list or “B” list.

The OIE is the international standard setting body for animal health and international trade. OIE categorizes animal diseases in two classes: “A” list (most serious) and “B” list (less serious). The “A” list contains transmissible diseases that have the potential for very serious and rapid spread, irrespective of national borders, are of serious socio-economic or public health consequence, and are of major importance in the international trade of animals and animal products. Diseases on the “A” list include the following: Foot and mouth disease; lumpy skin disease; bluetongue; African horse sickness; classical swine fever; vesicular stomatitis; rinderpest; contagious bovine pleuropneumonia; Rift Valley fever; sheep pox and goat pox; African swine fever; and highly pathogenic avian influenza. The “B” list diseases are transmissible diseases considered to be of socio-economic and/or public health importance within countries and are significant in the international trade of animals and animal products. This list currently includes over 100 diseases (Organization Internationale des Epizooties, January 9, 2003).

The Plant Protection and Quarantine (PPQ) program safeguards agriculture and natural resources from the risks associated with the entry, establishment, or spread of animal and plant pests and noxious weeds. Several thousand foreign plant and animal species have been established in the United States over the past 200 years, with approximately one in seven becoming invasive. An invasive species is an alien (i.e., non-native) species whose introduction does, or is likely to, cause harm to the economy, environment, or human health. Invasive plants, animals, and pathogens have often reduced the economic productivity and ecological integrity of agriculture, forestry, and other natural resources.

The Arizona Department of Agriculture (ADA) and Arizona Game and Fish Department (AGFD) are primarily concerned with plant, livestock and wild animal diseases and infections. These agencies focus on diseases listed on the Office International des Epizooties (OIE) disease “A” list. The OIE develops standards and guidelines for use in protecting against incursions of diseases or pathogens during trade in animals and animal products. The ADA and the AGFD are concerned with animal-to-animal diseases, as well as diseases transmitted from animals or arthropod vectors to humans.

As a part of the Sonoran Desert Conservation Plan (Pima County, 2002), Pima County identified and characterized a list of invasive, non-native plant and animal species that require attention. In that report, Pima County’s most serious invasive species problems were identified to be:

- Invasive African and Mediterranean grasses that present severe fire hazards to the Sonoran Desert ecosystem that did not evolve with fire and cannot survive with intense fires.

- Bullfrogs that eat native frogs, fish, snakes, and even bats and birds they catch flying over the water and crayfish that devour other aquatic plant and animal life, leaving streams with little life other than crayfish and algae.
- Saltcedar that invades riparian systems and displaces native plants while offering little benefit to most wildlife.
- Africanized bees that threaten humans and animal life.

Many other hazards, such as floods, earthquakes or droughts, may create conditions that significantly increase the frequency and severity of diseases. These hazards can affect basic services (e.g., water supply and quality, wastewater disposal, electricity), the supply and quality of food, and the public and agricultural health system capacities. As a result, concentrations of diseases may result and grow rapidly, potentially leading to large losses of life and economic value. In addition, since the anthrax attacks following the terrorist attacks on September 11, 2001, the threat of terrorism using disease to infest humans, animals, or plants, is of growing concern. This is particularly true of those capable of disrupting the human or animal food chain.

History

In Pima County, there have been seven disaster declarations (Presidential, USDA, or Gubernatorial disaster or emergency declaration) due to disease, as shown in Tables 5-2 and 5-3. There were no identified fatalities or injuries associated with these events as recorded. Major infectious disease outbreaks in Pima County that affected humans and animals include the following:

- In 1918 the Spanish influenza pandemic entered Arizona resulting in a great number of deaths, although the exact number is undocumented.
- In 1952, large numbers of influenza cases were reported throughout Arizona, including Pima County, although no death statistics are available.
- In 1975, a Rabies quarantine was issued for Pima County.
- On May 18, 2002 the Arizona Game and Fish Department placed an emergency ban on the importation of live hoofed animals (e.g., deer and elk) into Arizona due to a fear of Chronic Wasting Disease (CWD). CWD is a disease closely related to “mad cow disease” in cattle and scrapie in domestic sheep and goats, but also affects deer and elk (Arizona Game and Fish).
- On January 8, 2003, the Arizona Department of Agriculture issued an Administrative Order implementing procedures to prevent the introduction of Exotic Newcastle Disease (END) into Arizona. END is a contagious and fatal viral disease affecting domestic, wild, and caged poultry and birds, and is one of the most infectious diseases of poultry in the world. On February 5, 2003, Governor Napolitano declared a state of emergency to contain END threatening Arizona’s poultry. The US Secretary of Agriculture, Ann M. Veneman, signed declarations of extraordinary emergency with respect to END in Arizona on February 7, 2003 (United States Department of Agriculture, February 12, 2003).

Pima County has been subject to a number of major infestations, the largest of which is still affecting the state and region (pine bark beetle). Further details on these infestations are given below:

- Exotic and imported ants are listed on the Arizona Department of Agriculture website as “Arizona's Most Unwanted Pest”. Some people are allergic to the sting and in some cases may cause death. Fire ants are also known to out compete and drive away local native ants (Arizona Department of Agriculture).
- Arizona periodically experiences major grasshopper infestations. Four infestations have resulted in State declarations of emergency in the last quarter century (Arizona Division of Emergency Management, March 6, 2003).
- In 1996, a Karnal Bunt wheat plant disease disaster was declared. Other undeclared plant disease events include the citrus disease red scale in 1942 (ADEM, March 6, 2003).

- On May 22, 2003, Governor Janet Napolitano declared a State disaster and a state of emergency due to the ravages of the pine bark beetle on the state's forests. An estimated 2.5 million ponderosa pines and 4 million pinon pines were killed by the pine bark beetle in Arizona in 2002-2003. The last significant bark beetle outbreak in Arizona occurred from 1951 to 1956. The bark beetles are killing so many trees for two reasons, first the forest has too many trees and second the trees are very dry. Overcrowded forest conditions coupled with drought lead to the high probability of beetle attack. The forests of Arizona have been able to survive in relatively dry conditions because in past centuries low intensity fires helped to maintain a low density of trees in the forest. In the past century, however, fires have been controlled allowing many forested areas to become overcrowded (DeGomez, April 23, 2003).

Probability and Magnitude

The probability and magnitude of disease, particularly an epidemic, is difficult to evaluate due to the wide variation in disease characteristics, such as rate of spread, morbidity and mortality, detection and response time, and the availability of vaccines and other forms of prevention. A review of the historical record (see above) indicates that disease related disasters do occur in humans, animals, and plants with some regularity and severity. There is growing concern, however, about emerging infectious diseases as well as the possibility of a bioterrorism attack.

Vulnerability

Table 4-5: CPRI results for disease

Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Possible	Limited	> 24 hours	> 1 week	2.05
Oro Valley	Possible	Limited	> 24 hours	> 1 week	2.05
Pascua Yaqui Tribe	Possible	Limited	> 24 hours	> 1 week	2.05
Sahuarita	Possible	Limited	12 to 24 hours	< 1 week	2.20
Tucson	Possible	Limited	> 24 hours	> 1 week	2.05
Unincorporated Pima County	Likely	Critical	> 24 hours	< 1 week	2.70
				County-wide average CPRI =	**2.18**

Loss Estimations

The wide variation in disease characteristics makes evaluation of the vulnerability of people, animals, and plants difficult to analyze. Preventable diseases and injuries are studied and vulnerability assessments have been made. However, a highly contagious and severe disease, such as smallpox or a new strain of influenza, could swiftly kill large numbers of people and incapacitate critical facilities (e.g. hospitals). Although the vulnerability to people, animals and plants is valuable and desirable information for emergency planning purposes, a vulnerability assessment of the healthcare infrastructure would be invaluable in assessing the ability of hospitals, public health departments, clinics, urgent care centers and the like to ensure continued health care in all of Pima County should any one healthcare support system become inoperable or overwhelmed. Systems that should be included in a future vulnerability assessment study would include, but would not be limited to, local and outside pharmaceutical suppliers and their alternate sources, means of delivery, and timeframe; local laboratories and their alternate sources, means of delivery, and timeframe; general and specialized medical suppliers and their alternate sources, means of delivery and timeframe; and local military medical and hazardous materials support and possible alternate resources from the private sector to include means of delivery and timeframe.

Likewise, an animal equivalent, such as foot-and-mouth disease, could result in the destruction of numerous animals and cause tremendous economic impacts. The Arizona Department of Agriculture has identified numerous systemic, administrative, or organizational vulnerabilities that currently affect disease prevention in Arizona. Some of the more compelling factors that influence these vulnerabilities in Pima County include the following:

- Inspection services at all ports. No port has an animal inspector; most ports are manned by the Motor Vehicle Division and plant health inspection personnel who assist the Animal Services Division by visualizing animal health papers, without examining the animals.

- Safeguarding the food supply by inspecting commercial trucks destined for areas both inside and outside Arizona's borders.
- Continued observation of border crossings for animals arriving from Mexico after their USDA inspection.
- Create and enforce animal identification plan for cattle and horses in the United States.
- Prevent the illegal smuggling of fighting birds, pet birds, and other poultry; as well as meat products.
- The importation of shell eggs to the United States without USDA approval.
- Biosecurity at Arizona dairies, feedlots, and poultry producers.

Development Trends

Population growth in the county will increase the amount of people exposed to disease. Development within the county may also increase the risk of introducing or propagating invasive species if not monitored and regulated. Pima County citizens have taken an active role in mitigating disease and invasive species through numerous public and private programs, and will continue to do so.

Sources

Centers for Disease Control and Prevention, *Emerging Infectious Diseases: A Public Health Response.* http://www.cdc.gov/ncidod/emergplan/summary/summary.pdf

Centers for Disease Control and Prevention, 1994, *Addressing Emerging Infectious Disease Threats.* ftp://ftp.cdc.gov/pub/infectious_diseases/emergplan/pdf/emergplan.pdf

Centers for Disease Control and Prevention. May 2, 1997, *Facts About Disease Case Definitions.* http://www.cdc.gov/od/oc/media/fact/cases.htm

Centers for Disease Control and Prevention, October 1998, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century.* http://www.cdc.gov/ncidod/emergplan/plan98.pdf

Centers for Disease Control and Prevention, January 7, 2003, *CDC Finds Annual Flu Deaths Higher Than Previously Estimated* http://www.cdc.gov/od/oc/media/pressrel/r030107.htm

Centers for Disease Control and Prevention, May 2, 2003, *Summary of Notifiable Diseases, United States, 2001.* http://www.cdc.gov/mmwr/PDF/wk/mm5053.pdf

Centers for Disease Control and Prevention, July 8, 2003, *CDC Confirms Nation's First Human Case of West Nile in 2003.* http://www.cdc.gov/od/oc/media/pressrel/r030708.htm

Centers for Disease Control and Prevention, July 17, 2003, *Update to SARS Case Definition Reduces US Cases by Half.* http://www.cdc.gov/od/oc/media/pressrel/r030717a.htm

Lautner, Beth, April 18, 2002, *What is the National Health Emergency Management System (NEHMS)?* http://aphisweb.aphis.usda.gov/vs/training/lautner.pdf

Pima County, 2002, *An Invasive Species Management Program for Pima County, Sonoran Desert Conservation Plan*. http://www.pima.gov/cmo/sdcp/reports%5Cd26%5C136INVSP.PDF

4.4.2 Drought

Description

Drought is a normal part of virtually every climate on the planet, including areas of high and low rainfall. It is different from normal aridity, which is a permanent characteristic of the climate in areas of low rainfall. Drought is the result of a natural decline in the expected precipitation over an extended period of time, typically one or more seasons in length. The severity of drought can be aggravated by other climatic factors, such as prolonged high winds and low relative humidity (FEMA, 1997).

Drought is a complex natural hazard which is reflected in the following definitions commonly used to describe it:

- Meteorological – drought is defined solely on the degree of dryness, expressed as a departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales.
- Hydrological – drought is related to the effects of precipitation shortfalls on streamflows and reservoir, lake, and groundwater levels.
- Agricultural – drought is defined principally in terms of naturally occurring soil moisture deficiencies relative to water demands of plant life, usually arid crops.
- Socioeconomic – drought associates the supply and demand of economic goods or services with elements of meteorological, hydrologic, and agricultural drought. Socioeconomic drought occurs when the demand for water exceeds the supply as a result of weather-related supply shortfall. It may also be called a water management drought.

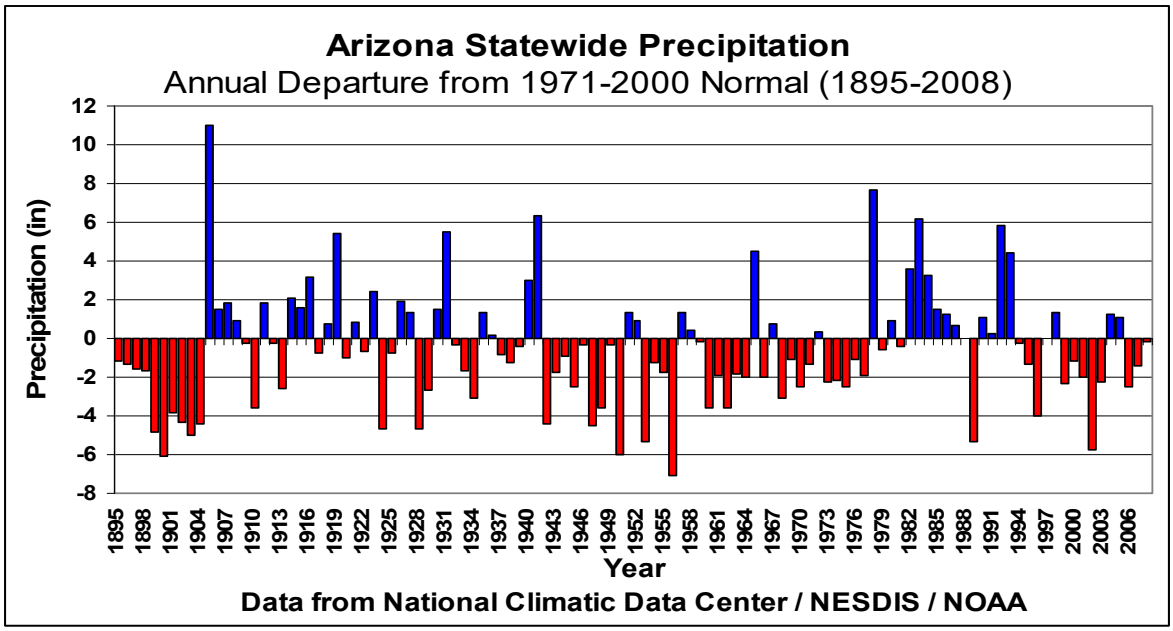
A drought's severity depends on numerous factors, including duration, intensity, and geographic extent as well as regional water supply demands by humans and vegetation. Due to its multi-dimensional nature, drought is difficult to define in exact terms and also poses difficulties in terms of comprehensive risk assessments.

Drought differs from other natural hazards in three ways. First, the onset and end of a drought are difficult to determine due to the slow accumulation and lingering effects of an event after its apparent end. Second, the lack of an exact and universally accepted definition adds to the confusion of its existence and severity. Third, in contrast with other natural hazards, the impact of drought is less obvious and may be spread over a larger geographic area. These characteristics have hindered the preparation of drought contingency or mitigation plans by many governments.

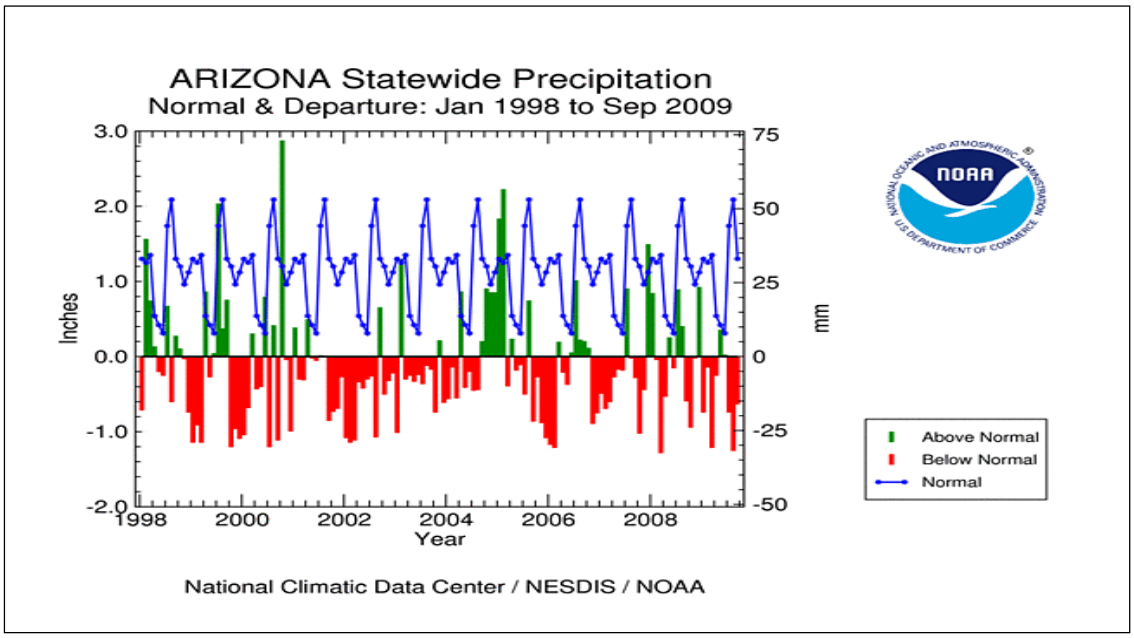
The effects of drought increase with duration as more moisture-related activities are impacted. Non-irrigated croplands are most susceptible to precipitation shortages. Rangeland and irrigated agricultural crops many not respond to moisture shortage as rapidly, but yields during periods of drought can be substantially affected. During periods of severe drought, lower moisture in plant and forest fuels create an increased potential for devastating wildfires. In addition, lakes, reservoirs, and rivers can be subject to water shortages that impact recreational opportunities, irrigated crops, and availability of water supplies for activities such as fire suppression and human consumption, and natural habitats of animals. Socioeconomic effects include higher unemployment and lower land values. Insect infestation can also be particularly damaging impact from severe drought conditions.

History

Arizona has experienced 17 droughts declared as drought disasters/emergencies and 93 drought events (droughts affecting multiple years are recorded as a distinct event for each year affected). Figures 5-1 and 5-2 depict the most recent precipitation data from NCDC regarding average statewide precipitation variances from normal. Between 1849 and 1905, the most prolonged period of drought conditions in 300 years occurred in Arizona (Jacobs, 2003). Another prolonged drought occurred during the period of 1941 to 1965. The period from 1979-1983 appears to have been anomalously wet, while the rest of the historical records shows that dry conditions are most likely the normal condition for Arizona. Between 1998 and 2008, there have been more months with below normal precipitation than months with above normal precipitation.



Average statewide precipitation variances from a normal based on 1971-2000 period

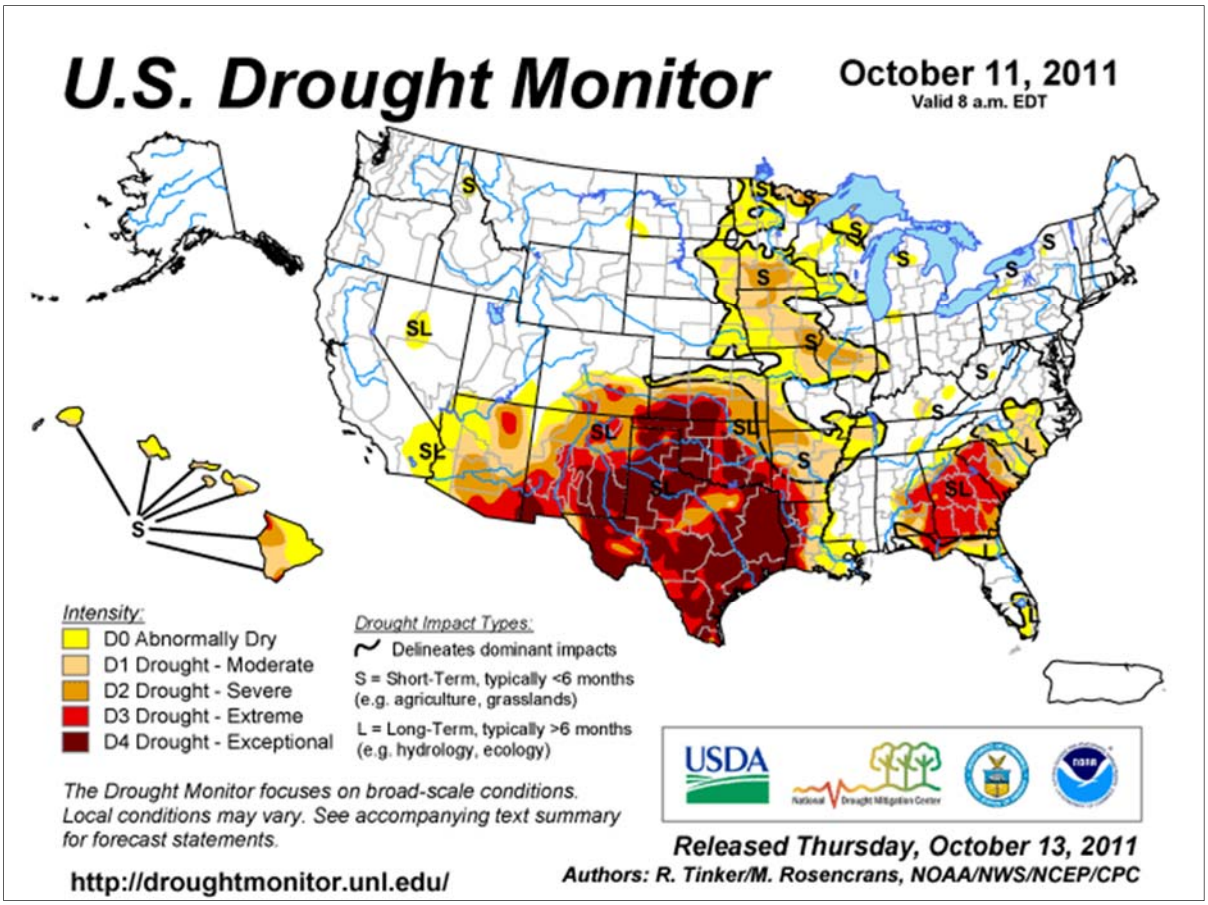


Average statewide precipitation variances from a normal based on 1998-2009 period

Probability and Magnitude

There is no commonly accepted return period or non-exceedance probability for defining the risk from drought (such as the 100-year or 1% annual chance of flood). The magnitude of drought is usually measured in time and the severity of the hydrologic deficit. There are several resources available to evaluate drought status and even project expected conditions for the very near future.

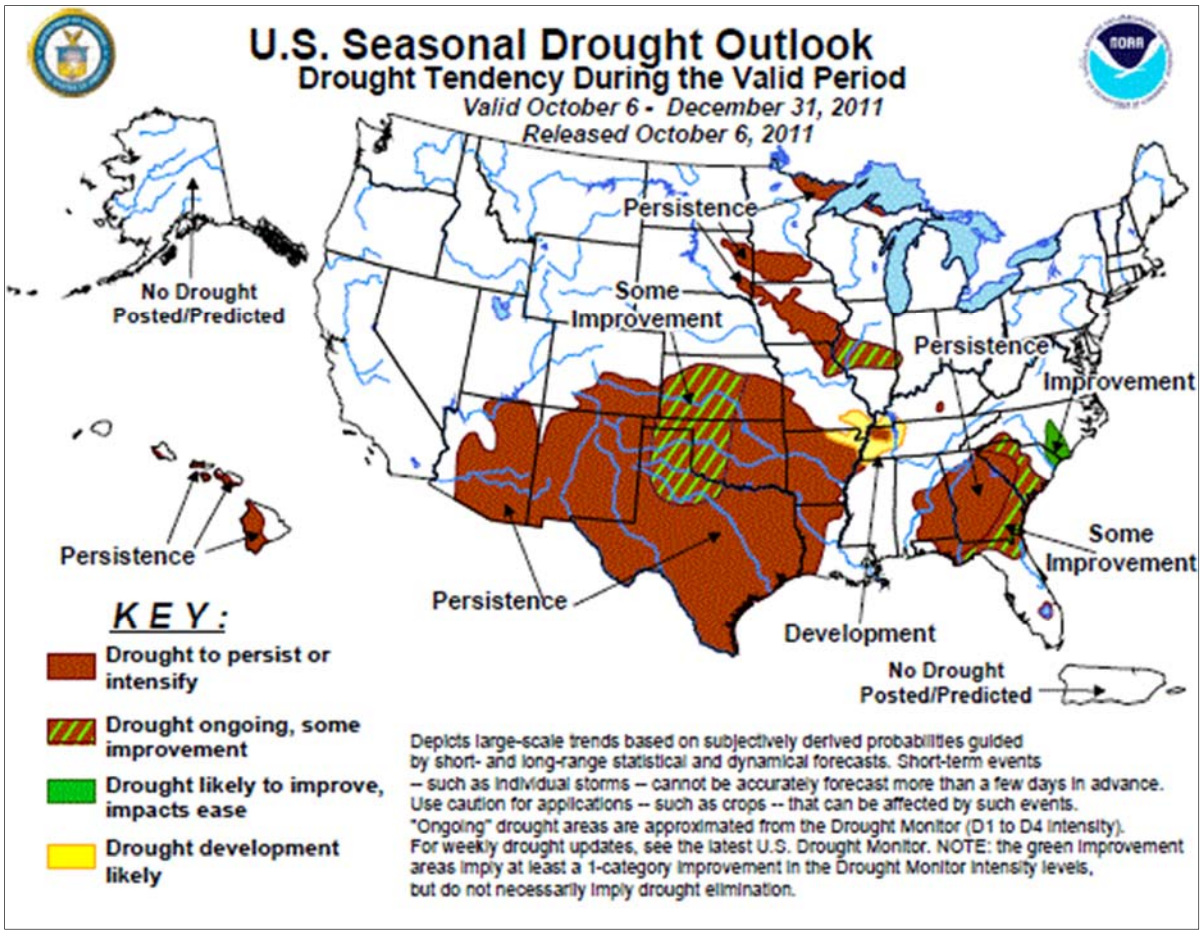
The National Integrated Drought Information System (NIDIS) Act of 2006 (Public Law 109-430) prescribes an interagency approach for drought monitoring, forecasting, and early warning (NIDIS, 2007). The NIDIS maintains the U.S. Drought Portal[12] which is a centralized, web-based access point to several drought related resources including the U.S. Drought Monitor (USDM) and the U.S. Seasonal Drought Outlook (USSDO). The USDM, shown in Figure 5-3, is a weekly map depicting the current status of drought and is developed and maintained by the National Drought Mitigation Center. The USSDO, shown in Figure 5-4, is a six month projection of potential drought conditions developed by the National Weather Service's Climate Prediction Center. The primary indicators for these maps for the Western U.S. are the Palmer Hydrologic Drought Index and the 60-month Palmer Z-index. The Palmer Drought Severity Index (PSDI) is a commonly used index that measures the severity of drought for agriculture and water resource management. It is calculated from observed temperature and precipitation values and estimates soil moisture. However, the Palmer Index is not considered to be consistent enough to characterize the risk of drought on a nationwide basis (FEMA, 1997) and neither of the Palmer indices are well suited to the dry, mountainous western United States.



Source: http://drought.unl.edu/dm/monitor.html

Map 4-1: U.S. Drought Monitor for October 11, 2011

[12] NIDIS U.S. Drought Portal website is located at: http://www.drought.gov/portal/server.pt/community/drought.gov/202



Source: http://www.cpc.ncep.noaa.gov/products/expert_assessment/seasonal_drought.html

Map 4-2: U.S. Seasonal Drought Outlook, October to December, 2011

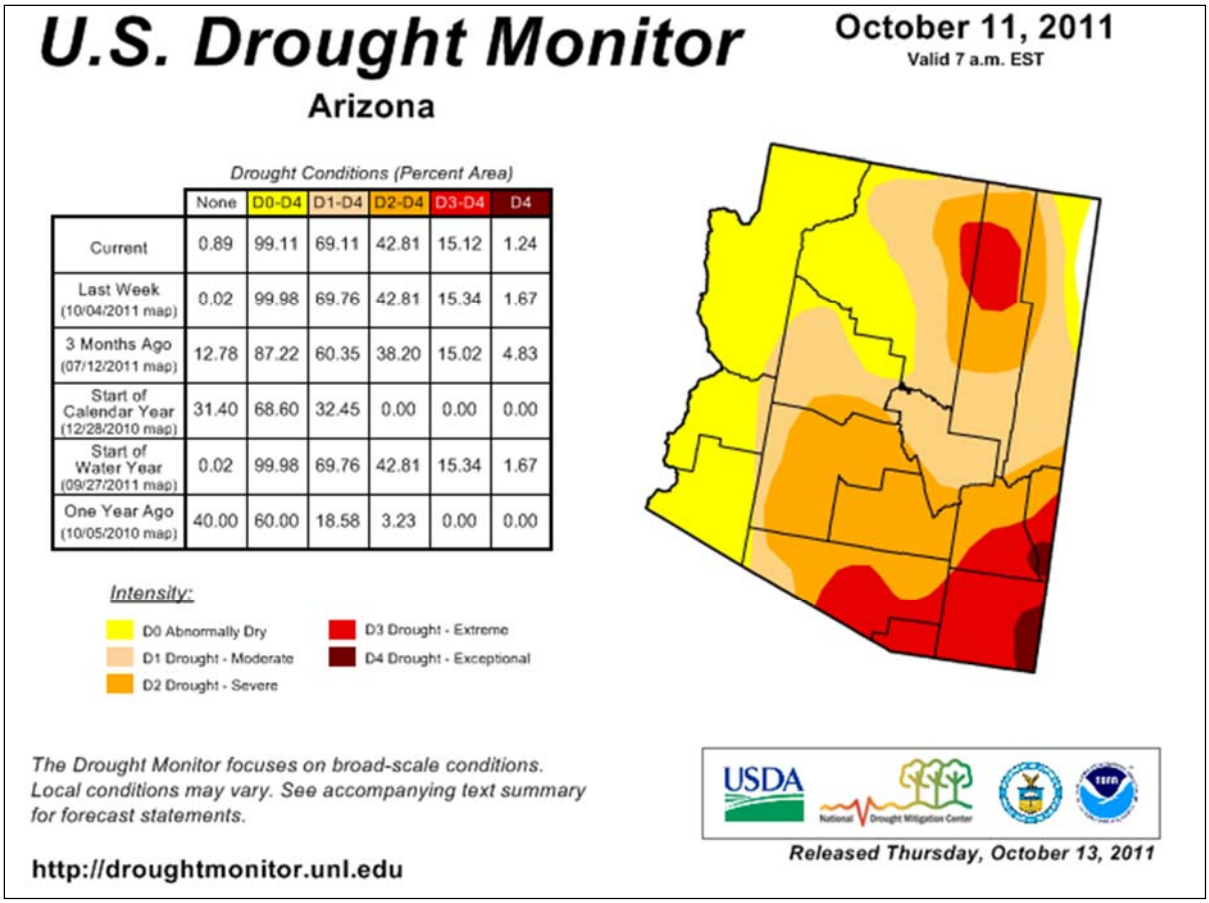
In 2003, Governor Janet Napolitano created the Arizona Drought Task Force (ADTF), led by ADWR, which developed a statewide drought plan. The plan includes criteria for determining both short and long-term drought status for each of the 15 major watersheds in the state using assessments that are based on precipitation and stream flow. The plan also provides the framework for an interagency group which reports to the governor on drought status, in addition to local drought impact groups in each county and the State Drought Monitoring Technical Committee. Twice a year this interagency group reports to the governor on the drought status and the potential need for drought declarations. The counties use the monthly drought status reports to implement drought actions within their drought plans. The State Drought Monitoring Technical Committee defers to the USDM for the short-term drought status and uses a combination of the Standardized Precipitation Index (SPI), evaporation and streamflow for the long-term drought status. Figures 5-5 and 5-6, present the most current short and long term maps available for Arizona as of the writing of this plan.

The current drought maps are in general agreement that Pima County is currently experiencing an abnormally dry to extreme drought condition for the short term and in a moderate drought condition for the long term. Figure 5-4 indicates that the drought conditions are projected to persist or intensify for Pima County over the next few months.

Vulnerability

Table 4-6: CPRI results for drought

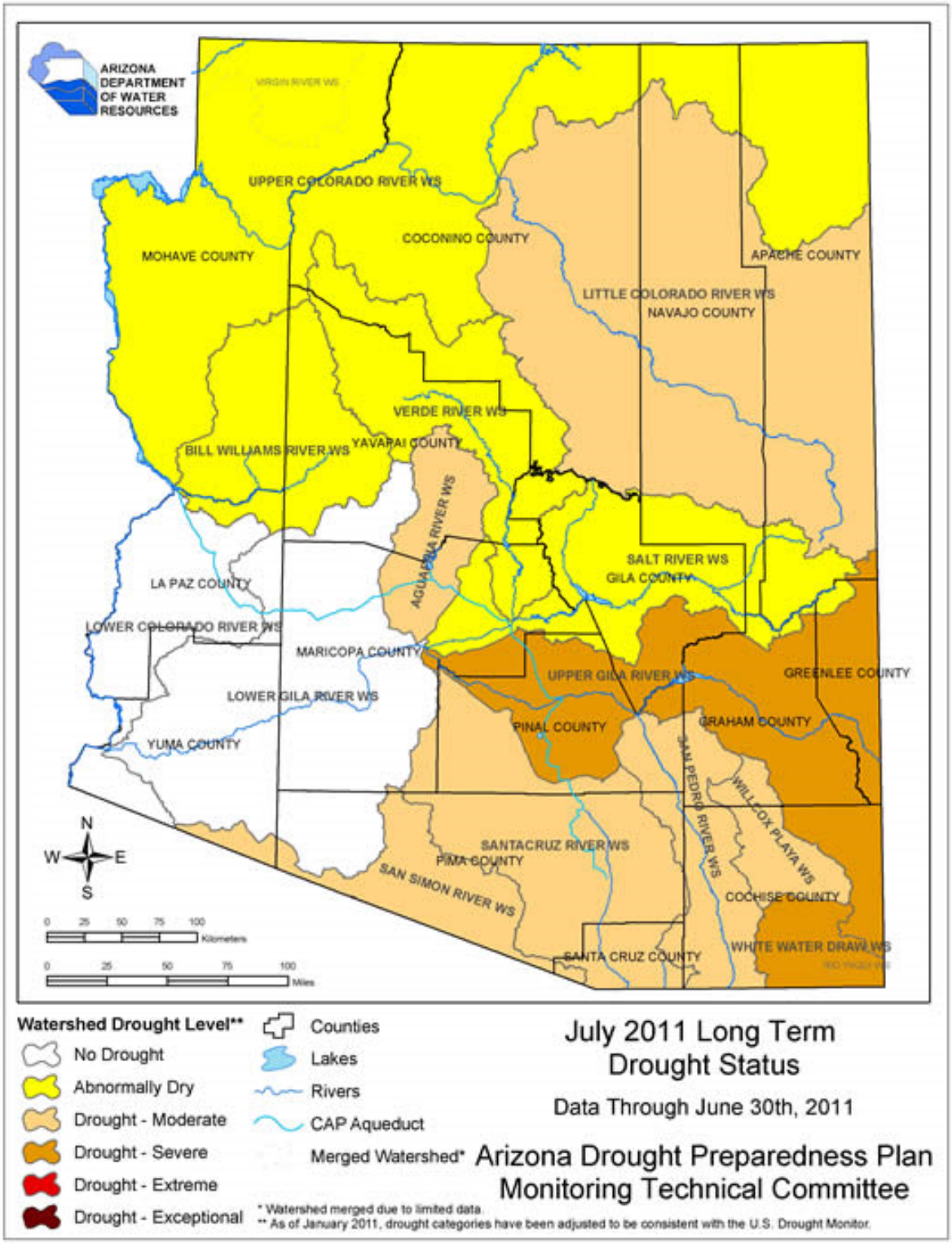
Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Possible	Limited	> 24 hours	> 1 week	2.05
Oro Valley	Likely	Critical	> 24 hours	> 1 week	2.80
Pascua Yaqui Tribe	Highly Likely	Limited	> 24 hours	> 1 week	2.95
Sahuarita	Highly Likely	Critical	> 24 hours	> 1 week	3.25
Tucson	Highly Likely	Critical	> 24 hours	> 1 week	3.25
Unincorporated Pima County	Highly Likely	Critical	> 24 hours	> 1 week	3.25
				County-wide average CPRI =	**2.93**



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.89	99.11	69.11	42.81	15.12	1.24
Last Week (10/04/2011 map)	0.02	99.98	69.76	42.81	15.34	1.67
3 Months Ago (07/12/2011 map)	12.78	87.22	60.35	38.20	15.02	4.83
Start of Calendar Year (12/28/2010 map)	31.40	68.60	32.45	0.00	0.00	0.00
Start of Water Year (09/27/2011 map)	0.02	99.98	69.76	42.81	15.34	1.67
One Year Ago (10/05/2010 map)	40.00	60.00	18.58	3.23	0.00	0.00

Source: http://www.adwr.state.az.us/AzDWR/StatewidePlanning/Drought/DroughtStatusMonitorPU.htm

Map 4-3: Arizona short term drought status for August 2009



Source: ADWR, 2010, *Arizona Drought Monitor Report - January 2010*

Map 4-4: Arizona long term drought status for July 2011

Loss Estimations

No standardized methodology exists for estimating losses due to drought and drought does not generally have a direct impact on critical and non-critical facilities and building stock, except perhaps water supply systems. A direct correlation to loss of human life due to drought is improbable for Pima County. Instead, drought vulnerability is primarily measured by its potential impact to certain sectors of the County economy and natural resources including:

- Crop and livestock agriculture
- Municipal and industrial water supply
- Recreation/tourism
- Wildlife and wildlife habitat

Sustained drought conditions will also have secondary impacts to other hazards such as fissures, flooding, subsidence and wildfire. Extended drought may weaken and dry the grasses, shrubs, and trees of wildfire areas, making them more susceptible to ignition. Drought also tends to reduce the vegetative cover in watersheds, and hence decrease the interception of rainfall and increase the flooding hazard. Subsidence and fissure conditions are aggravated when lean surface water supplies force the pumping of more groundwater to supply the demand without the benefit of recharge from normal rainfall.

According to the 2010 annual report of the Pima County Local Drought Impact Group, the following drought impacts were noted:

- At Cienega Creek, groundwater levels in three wells have dropped as much in the last year as they have in the last 15 years. Stream reaches are also shorter and the surface water volume is lower.
- Despite the warm, wetter summer weather patterns in eastern Pima County, water utilities continue to see a change in the peak high demand day. Usually occurring in mid- to late-June, the peak high water use day occurred in August and the peak was lower than in previous years.
- For ranchers, impacts to stock ponds and grasses continue to indicate drought conditions.

From 1995 to 2010, Pima County farmers and ranchers received $1.6 million in disaster related assistance funding from the U.S Department of Agriculture (USDA) for crop and livestock damages (EWG, 2011). Over $1.3 million of those funds were received during the time period of 2000 to 2005, which corresponds to the most severe period of the current drought cycle for Pima County.

Other direct costs such as increased pumping costs due to lowering of groundwater levels and costs to expand water infrastructure to compensate for reduced yields or to develop alternative water sources, are a significant factor but very difficult to estimate due to a lack of documentation. There are also the intangible costs associated with lost tourism revenues, and impacts to wildlife habitat and animals. Typically, these impacts are translated into the general economy in the form of higher food and agricultural goods prices and increased utility costs.

Development Trends

Population growth in Pima County will also require additional surface and ground water to meet the thirsty demands of potable, landscape, agricultural, and industrial uses. It is unlikely that significant growth will occur in the ranching and farming sectors given the current constraints on water rights, grazing rights, and available range land.

Pima County maintains a drought management website with drought related information and updates, and also facilitates the Pima County Local Drought Impact Group (LDIG), which is comprised of water providers and local, state, and federal agencies. Pima County has also developed a Drought Response Plan and Water Wasting Ordinance [13] that is administered and enforced through the Pima County Health Department for unincorporated areas of the county.

Drought planning should be a critical component of any domestic water system expansions or land development planning. The ADTF is also working cooperatively with water providers within the State to develop System Water Plans that are comprised of three components:

[13] A copy can be seen at: http://www.pima.gov/drought/PDFs/Drought_Ordinance.pdf

- *Water Supply Plan* – describes the service area, transmission facilities, monthly system production data, historic demand for the past five years, and projected demands for the next five, 10 and 20 years.
- *Drought Preparedness Plan* – includes drought and emergency response strategies, a plan of action to respond to water shortage conditions, and provisions to educate and inform the public.
- *Water Conservation Plan* – addresses measures to control lost and unaccounted for water, considers water rate structures that encourage efficient use of water, and plans for public information and education programs on water conservation.

The following are the major water providers that operate within Pima County and have developed System Water Plans with specific recommendations and requirements during times of drought:

- Tucson Water
- Marana
- Metro Water
- Flowing Wells Irrigation District
- Oro Valley
- Community Water Company of Green Valley

Sources

Arizona Department of Water Resources, *Arizona Drought Monitor Report - January 2010*

Arizona Division of Emergency Management, *State of Arizona Multi-Hazard Mitigation Plan*

Environmental Working Group's Farm Subsidy Database, 2011, http://farm.ewg.org/progdetail.php?fips=04019&progcode=total_dis&yr=mtotal

Federal Emergency Management Agency,1997, *Multi-Hazard Identification and Risk Assessment – A Cornerstone of the National Mitigation Strategy*.

Jacobs, Katharine and Morehouse, Barbara. June 11-13, 2003. "Improved Drought Planning for Arizona," from Conference on Water, Climate, and Uncertainty: Implications for Western Water Law, Policy and Management http://www.water.az.gov/gdtf/content/files/06262003/Improved_Drought_Planning_for_AZ_6-17.pdf

National Integrated Drought Information System, 2007, *National Integrated Drought Information System Implementation Plan*, NOAA.

NIDIS U.S. Drought Portal: http://www.drought.gov/portal/server.pt/community/drought.gov/202

NOAA, NWS, Climate Prediction Center, 2010, http://www.cpc.ncep.noaa.gov/products/expert_assessment/seasonal_drought.html

Pima County, 2011, Drought Management Website: http://www.pima.gov/drought/index.html

4.4.3 Earthquake

Description

An earthquake is a sudden motion or trembling caused by an abrupt release of accumulated strain within or along the edge of the Earth's tectonic plates. These rigid tectonic plates, some 50 to 60 miles thick, move slowly and continuously over the earth's interior, where they move away, past or under each other at rates varying from less than a fraction of an inch up to five inches per year. While this sounds small, at a rate of two inches per year, a distance of 30 miles would be covered in approximately one million years (FEMA, 1997). The tectonic plates continually bump, slide, catch, and hold as they move past each other which causes stress that accumulates along faults. When this stress exceeds the elastic limit of the rock, an earthquake occurs, immediately causing sudden ground motion and shaking. Secondary hazards may also occur, such as surface fault ruptures, ground failure, and tsunamis. While the majority of earthquakes occur near the edges of the tectonic plates, earthquakes may also occur in the interior of plates.

Ground motion is the vibration or shaking of the ground during an earthquake caused by the radiation of seismic waves. The severity of vibration generally increases with the amount of energy released and decreases with distance from the causative fault or epicenter of the earthquake. Additional factors, such as soft soils, can further amplify ground motions. Ground motion causes waves in the earth's interior, also known as seismic waves, and along the earth's surface, known as surface waves. Seismic waves include P (primary) waves and S (secondary) waves described as follows:

P (primary) waves are longitudinal or compressional waves similar in character to sound waves that cause back-and-forth oscillation along the direction of travel (vertical motion), with particle motion in the same direction as wave travel. They move through the earth at approximately 15,000 mph.

S (secondary) waves, also known as shear waves, are slower than P waves and cause structures to vibrate from side-to-side (horizontal motion) due to particle motion at right-angles to the direction of wave travel. Unreinforced buildings are more easily damaged by S waves.

Surface waves include Raleigh waves and Love waves. These waves travel more slowly and typically are significantly less damaging than seismic waves.

Seismic activity is commonly described in terms of magnitude and intensity. Magnitude (M) describes the total energy released and intensity (I) subjectively describes the effects at a particular location. Although an earthquake has only one magnitude, its intensity varies by location. Magnitude is the measure of the amplitude of the seismic wave and is expressed by the Richter scale. The Richter scale is a logarithmic measurement, where an increase in the scale by one whole number represents a tenfold increase in measured amplitude of the earthquake. Intensity is a measure of how strong the shock is felt at a particular location, expressed by the Modified Mercalli Intensity (MMI) scale.

Another way of expressing an earthquake's severity is to compare its acceleration to the normal acceleration due to gravity. If an object is dropped while standing on the surface of the earth (ignoring wind resistance), it will fall towards earth and accelerate faster and faster until reaching terminal velocity. The acceleration due to gravity is often called "g" and is equal to 9.8 meters per second squared (980 cm/sec/sec). This means that every second something falls towards earth, its velocity increases by 9.8 meters per second. Peak ground acceleration (PGA) measures the rate of change of motion relative to the rate of acceleration due to gravity. For example, acceleration of the ground surface of 244 cm/sec/sec equals a PGA of 25.0%.

It is possible to approximate the relationship between PGA, the Richter scale, and the MMI, as shown in Table 5-12. The relationships are, at best, approximate, and also depend upon such specifics as the distance from the epicenter and depth of the epicenter. An earthquake with 10.0% PGA would roughly correspond to an MMI intensity of V or VI, described as being felt by everyone, overturning unstable objects, or moving heavy furniture.

Table 4-7: Earthquake PGA, magnitude and intensity comparison

PGA (%g)	Magnitude (Richter)	Intensity (MMI)	Description (MMI)
<0.17	1.0 - 3.0	I	I. Not felt except by a very few under especially favorable conditions.

Table 4-7: Earthquake PGA, magnitude and intensity comparison

PGA (%g)	Magnitude (Richter)	Intensity (MMI)	Description (MMI)
0.17 – 1.4	3.0 - 3.9	II - III	II. Felt only by a few persons at best, especially on upper floors of buildings. III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
1.4 - 9.2	4.0 - 4.9	IV - V	IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motorcars rock noticeably. V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
9.2 – 34	5.0 - 5.9	VI - VII	VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
34 - 124	6.0 - 6.9	VII - IX	VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
>124	7.0 and higher	X or higher	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: Wald, Quitoriano, Heaton, and Kanamori, 1999.

One of the secondary hazards from earthquakes is surface faulting, the differential movement of two sides of a fault at the earth's surface. Linear structures built across active surface faults, such as railways, highways, pipelines, and tunnels, are at high risk to damage from earthquakes. Displacement along faults, both in terms of length and width, varies but can be significant (e.g., up to 20 feet), as can the length of the surface rupture (e.g., up to 200 miles).

Earthquake-related ground failure, due to liquefaction, is also a secondary hazard. Liquefaction occurs when seismic waves pass through saturated granular soil, distorting its granular structure, and causing some of the empty spaces between granules to collapse. Pore-water pressure may also increase sufficiently to cause the soil to behave like a fluid (rather than a soil) for a brief period, causing deformations. Liquefaction causes lateral spreads (horizontal movement commonly 10-15 feet, but up to 100 feet), flow failures (massive flows of soil, typically hundreds of feet, but up to 12 miles), and loss of bearing strength (soil deformations causing structures to settle or tip).

History

Seismic activity occurs on a regular basis throughout the State of Arizona, although most go undetected. Although rare, damaging earthquakes impacting Pima County have been recorded in the past as follows:

- The earliest recorded earthquake affecting Arizona, and possibly the largest, occurred in 1830. With an estimated Modified Mercalli Intensity (MMI) of IX recorded at San Pedro, AZ, approximately

25 miles west of Tucson, the earthquake would have caused massive damage to built structures (ADEM, March 1998).

- In 1887, the Sonoran earthquake caused significant destruction in southern Arizona towns, including Tucson, and was one of the largest earthquakes in North American history. The earthquake was caused by the reactivation of a basin and range normal fault that is similar to other faults in Arizona (DuBois & Smith, 1980). The epicenter was located approximately 100 miles south of Douglas, Arizona, along the Pitaycachi fault in Mexico, and caused great destruction at its epicenter. The earthquake was so large that it was felt from Guaymas, Mexico to Albuquerque, New Mexico. It is estimated variously to have been an intensity VII and magnitude 7.2 earthquake. In Arizona, water in tanks spilled over, buildings cracked, chimneys toppled, and railroad cars were set in motion. An observer at Tombstone, near the Mexican border, reported sounds ``like prolonged artillery fire" (ADEM, March 1998; Bausch & Brumbaugh, May 23, 1994; USGS, Sept. 12, 2003; Univ of AZ). With the increase in development, if such an earthquake occurred today it would cause extensive damage in southeastern Arizona (Jenny & Reynolds, 1989).

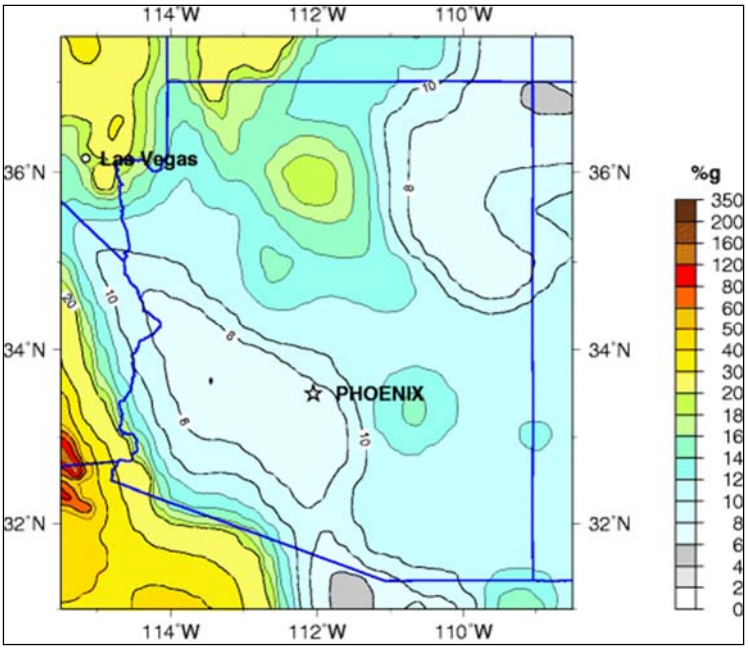
Probability/Magnitude

Probabilistic ground motion maps are typically used to assess the magnitude and frequency of seismic events. These maps estimate the probability of exceeding a certain ground motion, expressed as peak ground acceleration (PGA), over a specified period of years. For example, Figure 5-7 displays the probability of exceeding a certain ground motion, expressed as PGA, in 50 years in the Western United States. This is a common earthquake measurement that shows three things: the geographic area affected (colored areas on map below); the probability of an earthquake of each level of severity (e.g., 2% chance in 50 years); and the severity (PGA) as indicated by color.

Note that Figure 5-7 expresses a 2% probability of exceedance and, therefore, there is a 98% chance that the peak ground acceleration displayed will not be exceeded during 50 years. The use of a 50-year return period is based on statistical significance and does not imply that the structures are thought to have a useful life of only 50 years. Similar maps exist for other measures of acceleration, probabilities, and time periods.

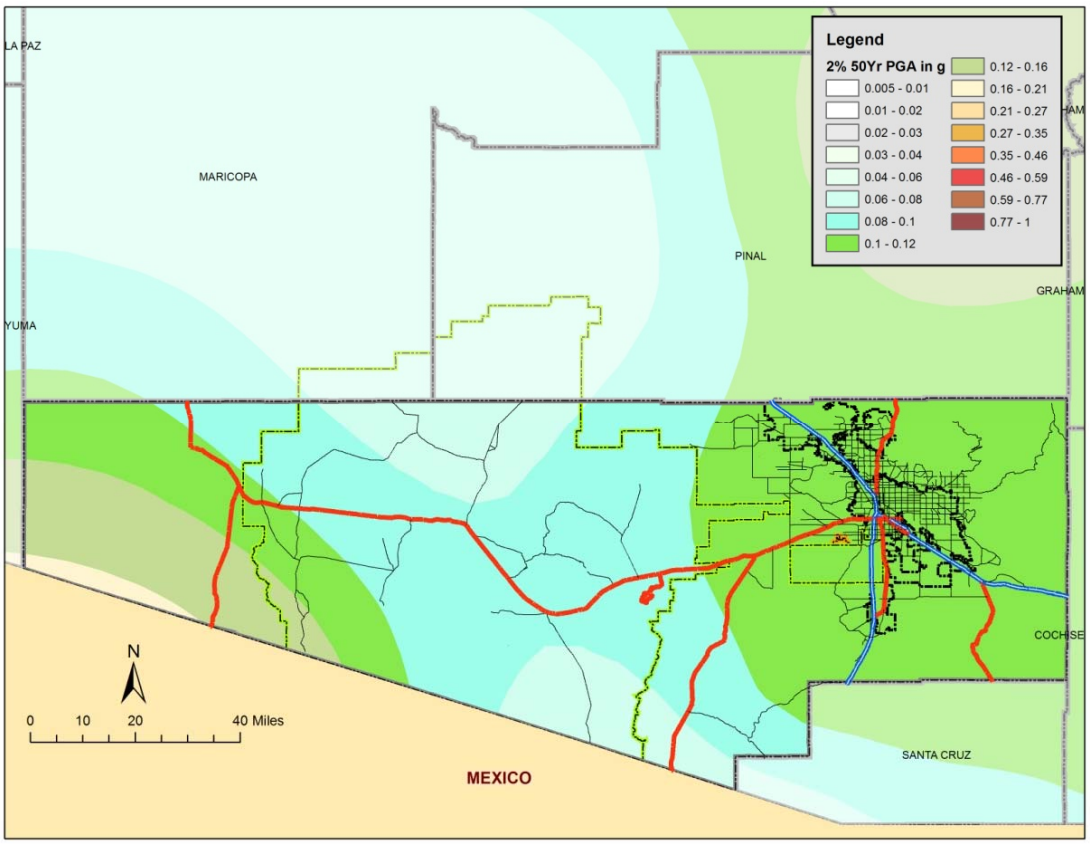
It is useful to note that according to the USGS, a PGA of approximately 10% gravity (0.10 g) is the approximate threshold of damage to older (pre-1965) dwellings or dwellings not made resistant to earthquakes. The 0.10 g measure was chosen because, on average, it corresponds to the MMI VI to VII levels of threshold damage in California within 25 km of an earthquake epicenter.

Figure 5-8 provides a more detailed view of the 2%, 50-year PGA map for Pima County. As demonstrated by this map, the central portion of Pima County has a PGA that ranges between 0.06g and 0.10g. The eastern third of the county is within the 0.10g to 0.12g range. The western portion of the county ranges from 0.08g to 0.16g with the highest PGA values occurring along the Yuma County and Mexico border. Overall, PGA values for Pima County are low in comparison with other counties within the State, and especially in areas of high population.



Source: USGS, 2008

Peak ground acceleration for a 2% chance in 50 years recurrence



Source: USGS, 2008; JEF, 2011

PGA for a 2% chance in 50 years recurrence

In general, the risk of seismic hazard in the urbanized portions of Pima County are relatively low; however, denser populations, existence of high rise buildings, existence of unreinforced masonry buildings, and the lack of earthquake awareness among its population elevate the risks associated with seismic activity.

The rate of seismicity in Pima County has historically been low, with the area's most recent quakes originating in San Luis in 1976 (M 6) and Baja, Mexico in 2010 (M 7.2). The largest impact of an earthquake on the metropolitan area would be the economic impact from a catastrophic southern California earthquake, which would disrupt approximately 60% of Arizona's fuel and 90% of Arizona's food goods. The Tucson metropolitan area could also be significantly affected by a major quake in the Yuma or Northern Arizona Seismic Belt (NASB). A repeat of the 1887 earthquake would result in significant damage to Arizona's population centers, particularly where development is located on alluvial plains and steep slopes. It should also be noted that although the small earthquakes occurring in Pima County are of low seismic risk to buildings, the repeated shaking could eventually cause structural damage. In unstable areas, small earthquakes may also trigger landslides and boulders rolling off mountain slopes (Jenny and Reynolds, 1989).

Vulnerability

Table 4-8: CPRI results for earthquake

Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Possible	Critical	< 6 hours	> 1 week	2.80
Oro Valley	Possible	Limited	< 6 hours	< 6 hours	2.20
Pascua Yaqui Tribe	Possible	Limited	< 6 hours	< 6 hours	2.20
Sahuarita	Possible	Negligible	< 6 hours	< 24 hours	2.00
Tucson	Possible	Limited	< 6 hours	> 1 week	2.50
Unincorporated Pima County	Possible	Limited	< 6 hours	< 1 week	2.40
				County-wide average CPRI =	**2.35**

Loss Estimations

The 2007 Plan estimated seismic related losses to general residential and commercial buildings using the HAZUS-MH® program. As of the writing of this Plan, the HAZUS-MH® database has not been updated to reflect the 2010 Census data and is therefore unchanged since the 2007 Plan analyses were performed. Accordingly, the 2007 Plan residential and commercial loss estimates for earthquake will be carried forward with this Plan for the next 5 year cycle. By the end of that period, FEMA will have updated the HAZUS database to reflect current building counts. It is noted that all residential and commercial loss estimates are determined using the HAZUS database, which is based on 2000 Census data.

The earthquake hazard assessment utilized the HAZUS-MH software model including the following data: 100-, 250-, 500-, 750-, 1000-, 1500-, 2000-, and 2500- year return period USGS probabilistic hazards. Developed for FEMA by the National Institute of Building Sciences (NIBS), HAZUS-MH integrates earthquake hazard modeling with GIS technology to determine the following annualized loss estimates for each jurisdiction:

- The aggregated population at risk at the census block level,
- The aggregated exposure and building count at the census block level for residential and commercial occupancies, and,
- The critical infrastructure at risk.

The earthquake risk assessment performed for Pima County did not explore the potential for collateral hazards such as liquefaction or landslide. However, losses associated with these ground failures would have been negligible given the level of shaking expected for Pima County (i.e., not enough strong shaking to trigger significant ground failure).

The annualized loss estimates developed represent the average of all eight of the modeled return periods (100-year through 2,500-year events). Table 5-14 provides a breakdown of potential exposure and losses due to annualized earthquake events by jurisdiction. Approximately 980,263 people may be at risk from earthquake hazards within Pima County. Annualized losses associated with earthquakes in Pima County may be expected to cause $3.1 million in damage to residential buildings and $310,000 in damage to commercial buildings. These anticipated losses are expected to equate to a countywide loss-to-exposure ratio of less than 0.0007.

The largest potential annualized losses to jurisdictions in Pima County include the City of Tucson and the unincorporated portions of Pima County. Together these jurisdictions account for $2.6 million in residential losses and $273,000 in commercial losses equating to 84% and 88% respectively of the total losses countywide.

Table 4-9: Potential exposure and loss from earthquake hazard

		Residential (From 2007 Plan)				Commercial (From 2007 Plan)				Critical Facilities	
Jurisdiction	Exposed Population	Building Count	Potential Loss (x $1000)	Potential Exposure (x $1000)	Loss Ratio	Building Count	Potential Loss (x $1000)	Potential Exposure (x $1000)	Loss Ratio	Facility Count	Potential Exposure (x $1000)
Marana	34,961	5,525	$130	$805,901	.00016	60	$8	$108,214	.00007	272	$765,099
Oro Valley	41,011	13,920	$170	$2,350,794	.00007	26	$7	$58,925	.00012	68	$395,165
Pascua Yaqui Tribe	3,745	646	$5	$46,231	.00011	2	Negligible	$2,308	.00022	16	$311,366
Sahuarita	25,259	1,290	$64	$188,135	.00034	9	$3	$18,133	.00017	76	$278,952
South Tucson	5,652	1,161	$31	$201,073	.00015	21	Negligible	$39,180	.00001	19	$48,227
Tohono O'odham	9,051	2,541	$86	$291,786	.00030	14	$14	$29,234	.00048	108	$234,840
Tucson	520,116	135,602	$1,408	$23,218,546	.00006	1,682	$179	$3,267,100	.00006	1,625	$6,467,814
Unincorporated	340,468	116,590	$1,256	$16,064,814	.00008	441	$94	$975,375	.00010	1,302	$3,449,956
Total	980,263	277,275	$3,150	$43,167,280	.00007	2,255	$310	$4,498,469	.00007	3,486	$11,951,419

Development Trends

In general, the earthquake risk in the identified growth areas of the Pima County jurisdictions is at the borderline of the 10% g PGA, which as previously stated, is the approximate threshold of damage for older (pre-1965) dwellings or dwellings not made resistant to earthquakes. The Throughout the county, new development is typically regulated to be in compliance with current building codes that will provide for more stable seismic designs of new construction.

Sources

AZ Earthquake Information Center. NAU seismic network: http://www4.nau.edu/geology/aeic/aeic.html

AZ Integrated Seismic Network. Eight broadband seismometer – http://www.azgs.az.gov/fema_award.shtml for locations and access to daily records.

Beyer, Scott, and Pearthree, P.A., 1994, *Bibliography of earthquake hazards in Arizona*: Arizona Geological Survey Open-File Report 94-03, 44 p.

DuBois, S.M., and Smith, A.W., 1980, *The 1887 earthquake in San Bernardino Valley, Sonora; historic accounts and intensity patterns in Arizona*: Arizona Bureau of Geology and Mineral Technology Special Paper no. 3, 112 p.

DuBois, S.M., Smith, A.W., Nye, N.K., and Nowak, T.A., Jr., 1982, *Arizona earthquakes, 1776-1980*: Arizona Bureau of Geology and Mineral Technology Bulletin 193, 456 p., 1 sheet, scale 1:1,000,000.

Geologic Map of Arizona. 2000, Product of the AZGS, http://www.azgs.az.gov/services_azgeomap.shtml

Pearthree, P.A., and Calvo, S.S., 1987, *The Santa Rita fault zone: Evidence for large magnitude earthquakes with very long recurrence intervals in the Basin and Range province of southeastern Arizona*: Seismological Society of America, Bulletin, v. 77, no. 1, p. 97-116.

Earthquake Hazards Program, 2009, US Geological Survey: http://earthquake.usgs.gov/hazards/products/conterminous/

P.A. Pearthree and D.B. Bausch, 1999, *Earthquake hazards in Arizona*: AZGS Map 34, text and map, scale 1:1,000,000.

P.A. Pearthree, compiler, 1998, *Quaternary fault data and map for Arizona*: AZGS OpenFile Report 9824, 122 p., scale 1:750,000, 1 disk.

P.A. Pearthree and others, 1996, *PlioQuaternary faulting and seismic hazard in the Flagstaff area, northern Arizona*: AZGS Bulletin 200, 40 p., 2 sheets, scale 1:50,000 and 1:100,000.

D.B. Bausch and D.S. Brumbaugh, 1994, *Seismic hazards in Arizona:* Flagstaff, AZ Earthquake Information Center, 49 p., 2 sheets, scale 1:1,000,000.

S.M. DuBois and others, 1982, *Arizona earthquakes*: AZGS Bulletin 193, 456 p., scale 1:1,000,000.

DuBois/A.W. Smith, 1980, *The 1887 earthquake in San Bernardino Valley, Sonora: Historic accounts & intensity patterns in AZ*: AZGS Special Paper 3, 112 p.

Arizona State University, May 26, 2003."Earthquake information for the State of Arizona & the world." http://activetectonics.la.asu.edu/e-quakes/

Bausch, Douglas B. and David S. Brumbaugh, May 23, 1994. Seismic Hazards in Arizona –Arizona Ground Shaking Intensity & 100 yr Acceleration Contour Maps, http://www4.nau.edu/geology/aeic/staterep.txt

Jenny, J.P. and S.J. Reynolds, 1989. "Geologic Evolution of Arizona" in Arizona Geological Society Digest, No. 17.

Petersen, Mark D., Frankel, Arthur D., Harmsen, Stephen C., Mueller, Charles S., Haller, Kathleen M., Wheeler, Russell L., Wesson, Robert L., Zeng, Yuehua, Boyd, Oliver S., Perkins, David M., Luco, Nicolas, Field, Edward H., Wills, Chris J., and Rukstales, Kenneth S., 2008, Documentation for the 2008 Update of the United States National Seismic Hazard Maps: U.S. Geological Survey Open-File Report 2008–1128, 61 p.

US Geological Survey (USGS):

- February 7, 2003, "Definition of %g – What is the relation to Building Damage?" http://geohazards.cr.usgs.gov/eq/faq/parm02.html
- September 12, 2003, "Earthquake History of Arizona." http://wwwneic.cr.usgs.gov/neis/states/arizona/arizona_history.html

Wald, David J., Vincent Quitoriano, Thomas H. Heaton and Hiro Kanamori,1999. "Relationship between Peak Ground Acceleration, Peak Ground Motion and Modified Mercalli Intensity in California" in Earthquake Spectra, Vol. 15, No. 3, 557-564. http://pasadena.wr.usgs.gov/shake/pubs/regress/regress.html

4.4.4 Extreme Temperature

Description

Extreme temperatures on either the cold or hot side of the thermometer can occur within any area and can often have adverse impacts on the health and welfare of a community or region. These extreme temperatures can impact people, pets, plants and infrastructure such as power lines and above and below-ground pipes throughout the area.

Extreme heat is the combination of very high temperatures and exceptionally humid conditions that exceed regionally based indices for perceived risk. According to the National Weather Service, heat is the leading weather-related killer in the United States and has killed more people than lightning, tornadoes, floods and hurricanes combined in the last 10 years. The major human risks associated with extreme heat are as follows:

- Heat Cramps: May occur in people unaccustomed to exercising in the heat and generally ceases to be a problem after acclimatization.
- Heat Syncope: This refers to sudden loss of consciousness and is typically associated with people exercising who are not acclimated to warm temperatures. Causes little or no harm to the individual.
- Heat Exhaustion: While much less serious than heatstroke, heat exhaustion victims may complain of dizziness, weakness, or fatigue. Body temperatures may be normal or slightly to moderately elevated. The prognosis is usually good with fluid treatment.
- Heatstroke: Considered a medical emergency, heatstroke is often fatal. It occurs when the body's responses to heat stress are insufficient to prevent a substantial rise in the body's core temperature. While no standard diagnosis exists, a medical heatstroke condition is usually diagnosed when the body's temperature exceeds 105°F due to environmental temperatures. Rapid cooling is necessary to prevent death, with an average fatality rate of 15% even with treatment.

Extreme cold is normally associated with northern climates and regions, but in reality is much like extreme heat in that it is relative to what is considered normal cold temperatures for a region. In Arizona sustained below freezing temperatures can prove to be dangerous and damaging. For example, economic losses due to frozen crops, downed power lines, or burst pipelines can be significant. Sustained conditions of freezing temperatures can also pose a dangerous health risk to people and their animals.

History

Extreme temperature events occur in Pima County on a regular basis, but the damaging events typically occur during the summer and winter months. The following are examples of documented past events:

- According to a report prepared by the Arizona Dept of Health Services (ADHS, 2010), a total of 624 heat related deaths have occurred in Pima County over the period of 1992-2009, with the majority occurring between 2000 and 2009.
- Deaths of illegal immigrants in the desert areas along the Arizona-Mexico border are also attributed to extreme heat. In 2005, roughly 80 migrants died in the Tucson sector alone from heat exposure, while more than 180 total deaths occurred from heat exposure along the border (Guido, 2008).
- In February 2011, record breaking cold blanketed the southern portion of Arizona. Temperatures in Pima County ranged from 15 to 20° and with the wind chill factor, the estimates went as low as 0°. Across the County, individual water pipes were either frozen or burst, closing businesses, schools, and government buildings. Freezing temperatures shut down some Tucson Water pumps overnight, leaving over 1,000 homes and business without water service. About 14,000 natural gas customers in Tucson's Rita Ranch and eastern Foothills had gas service shut-off due to low main line pressures emanating from Texas. Tucson opened two shelters for those without heat and dozens of area schools were closed (Tucson Sentinel, 2011).

Probability and Magnitude

There are no recurrence or non-exceedance probabilities developed for extreme temperature events in Arizona or Pima County. Table 4-1 in Section 4 provides example normal and extreme temperature ranges for various weather stations within the county. In general, extreme temperatures vary from normal by 10 to over 30°, with highs that exceed 110° and lows extending into the 5-10°F range.

One indicator of the degree of danger associated with extreme heat is the Heat Index (HI) or the "Apparent Temperature". According the NWS, the HI is an accurate measure of how hot it really feels when the Relative Humidity (RH) is added to the actual air temperature. Figure 5-9 is a quick reference chart published by the NWS that shows the HI based on current temperature and relative humidity, and levels of danger for HI values. It should be noted that the HI values were devised for shady, light wind conditions and that exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

Relative Humidity (%)

Temperature (°F)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
80	77	78	78	79	79	79	80	80	80	81	81	82	82	83	84	84	85	86	86	87
81	78	79	79	79	79	80	80	81	81	82	82	83	84	85	86	86	87	88	90	91
82	79	79	80	80	80	80	81	81	82	83	84	84	85	86	88	89	90	91	93	95
83	79	80	80	81	81	81	82	82	83	84	85	86	87	88	90	91	93	95	97	99
84	80	81	81	81	82	82	83	83	84	85	86	88	89	90	92	94	96	98	100	103
85	81	81	82	82	82	83	84	84	85	86	88	89	91	93	95	97	99	102	104	107
86	81	82	83	83	83	84	85	85	87	88	89	91	93	95	97	100	102	105	108	112
87	82	83	83	84	84	85	86	87	88	89	91	93	95	98	100	103	106	109	113	116
88	83	84	84	85	85	86	87	88	89	91	93	95	98	100	103	106	110	113	117	121
89	84	84	85	85	86	87	88	89	91	93	95	97	100	103	106	110	113	117	122	
90	84	85	86	86	87	88	89	91	92	95	97	100	103	106	109	113	117	122	127	
91	85	86	87	87	88	89	90	92	94	97	99	102	105	109	113	117	122	126	132	
92	86	87	88	88	89	90	92	94	96	99	101	105	108	112	116	121	126	131		
93	87	88	89	89	90	92	93	95	98	101	104	107	111	116	120	125	130	136		
94	87	89	90	90	91	93	95	97	100	103	106	110	114	119	124	129	135	141		
95	88	89	91	91	93	94	96	99	102	105	109	113	118	123	128	134	140			
96	89	90	92	93	94	96	98	101	104	108	112	116	121	126	132	138	145			
97	90	91	93	94	95	97	100	103	106	110	114	119	125	130	136	143	150			
98	91	92	94	95	97	99	102	105	109	113	117	123	128	134	141	148				
99	92	93	95	96	98	101	104	107	111	115	120	126	132	138	145	153				
100	93	94	96	97	100	102	106	109	114	118	124	129	136	143	150	158				
101	93	95	97	99	101	104	108	112	116	121	127	133	140	147	155					
102	94	96	98	100	103	106	110	114	119	124	130	137	144	152	160					
103	95	97	99	101	104	108	112	116	122	127	134	141	148	157	165					
104	96	98	100	103	106	110	114	119	124	131	137	145	153	161						
105	97	99	102	104	108	112	116	121	127	134	141	149	157	166						
106	98	100	103	106	109	114	119	124	130	137	145	153	162	172						
107	99	101	104	107	111	116	121	127	134	141	149	157	167							
108	100	102	105	109	113	118	123	130	137	144	153	162	172							
109	100	103	107	110	115	120	126	133	140	148	157	167	177							
110	101	104	108	112	117	122	129	136	143	152	161	171								
111	102	106	109	114	119	125	131	139	147	156	166	176								
112	104	107	111	115	121	127	134	142	150	160	170	181								
113	104	108	112	117	123	129	137	145	154	164	175									
114	105	109	113	119	125	132	140	148	158	168	179									
115	106	110	115	121	127	134	143	152	162	173	184									
116	107	111	116	122	129	137	146	155	166	177										
117	108	112	118	124	132	140	149	159	170	181										
118	108	113	119	126	134	142	152	162	174	186										
119	109	114	121	128	136	145	155	166	178											
120	110	116	122	130	138	148	158	170	182											
121	111	117	124	132	141	151	162	174	187											
122	111	118	125	134	143	154	165	178												
123	112	119	127	136	146	157	169	182												
124	113	120	129	138	148	160	172													
125	114	121	130	140	151	163	176													

Heat Index

Extreme Danger	Heat stroke likely.
Danger	Sunstroke, musde cramps, and/or heat exhaustion likely. Heatstroke possible with prolonged exposure and/or physical activity.
Extreme Caution	Sunstroke, musde cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Caution	Fatigue possible with prolonged exposure and/or physical activity.

National Weather Service Heat Index Chart

Vulnerability

Table 4-10: CPRI results for extreme temperature

Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Likely	Limited	> 24 hours	> 1 week	2.50
Oro Valley	Highly Likely	Critical	> 24 hours	> 1 week	3.25
Pascua Yaqui Tribe	Highly Likely	Limited	> 24 hours	< 1 week	2.85
Sahuarita	Highly Likely	Catastrophic	6 to 12 hours	< 1 week	3.75
Tucson	Highly Likely	Negligible	> 24 hours	> 1 week	2.65
Unincorporated Pima County	Highly Likely	Limited	< 6 hours	< 6 hours	3.10
				County-wide average CPRI =	**3.02**

Loss Estimations

Losses due to extreme heat or cold primarily occur in the form of death and illness for people and animals, and infrastructure damage that is primarily associated with extreme cold. There are currently no statistical analyses for projecting heat or cold related deaths in the State, however, ADHS does track data and monitor trends and other factors to determine if a statistical significance exists. Past history would indicate that multiple deaths due to extreme heat are highly likely, and especially for illegal immigrants that attempt to cross the Arizona deserts during the summer months. The homeless and low income populations are particularly vulnerable to extreme temperatures due to the increased exposure to the natural elements and decreased ability to compensate in the form of heating and cooling apparatus. Property and infrastructure damages are typically associated with hard freezes.

Development Trends

Growth in Pima County over the past five years has significantly increased the amount population and infrastructure exposed to extreme temperatures. There is also an increased demand on resources such as power in summers and natural gas in the winter. The primary intersect of extreme temperature hazards and future development of the county is in the general increase in population and infrastructure that would be exposed. Advanced building codes requiring adequate burial depth of water lines are generally being used and enforced.

Over the past two decades, as the metropolitan area has dramatically grown in size the "urban heat island" effect has developed, which cause temperatures in the center of metropolitan areas to become much warmer than those in rural areas. The concrete and asphalt of urban areas retains the heat of the day, and releases it slowly as compared to the surrounding desert terrain, which cools much quicker at night. As development continues to occur within Tucson and its environs, heat conditions will continue to increase.

Sources

AZ Dept of Health Services, 2004, Prevention Bulletin, Volume 18, No. 4, http://www.azdhs.gov/diro/pio/preventionbulletin/july04.pdf

FEMA,1997, Multi-Hazard Identification & Risk Assessment – A Cornerstone of the Nat'l Mitigation Strategy.

Guido, Zack, 2008, *Anticipating Summer Heat – A Look at the Impacts and Extreme Temperatures in the Southwest*, Southwest Climate Outlook, May 2008 Issue, University of Arizona, CLIMAS, http://www.ispe.arizona.edu/climas/forecasts/swarticles.html

Maricopa County Department of Public Health, Division of Disease Control, Office of Epidemiology and Data Services, 2009, Heat Caused and Heat Related Death Occurrences in Maricopa County, http://www.maricopa.gov/Public_Health/EPI/pdf/heat/2008annualreport.pdf

Mrela, C. K., Torres, C., 2009, *Deaths from Exposure to Excessive Natural Heat Occurring in Arizona, 1992-2009*, Arizona Department of Health Services, available a the following URL: http://www.azdhs.gov/plan/report/heat/heat09.pdf

NASA, 2010, *NASA Assets Provide Orbital View to Study Phoenix Heat Waves*, http://www.nasa.gov/centers/johnson/home/phoenix_heatwaves_feature_prt.htm

National Weather Service, Warning and Forecast Office – Phoenix, 2009, http://www.wrh.noaa.gov/psr/general/safety/heat/

Tucson Sentinel, 2011, articles at the following URLs: http://www.tucsonsentinel.com/local/report/020311_tucson_water_freeze/cold-shuts-down-some-tucson-water-pumps/ http://www.tucsonsentinel.com/local/report/020311_heat_shelters/cold-pueblo-thousands-without-heat-city-opens-shelters/

UofA Library, *Books of the Southwest* http://southwest.library.arizona.edu/azso/body.1_div.3.html

4.4.5 Flood / Flash Flood

Description

For the purpose of this Plan, the hazard of flooding addressed in this section will pertain to floods that result from precipitation/runoff related events. Other flooding due to dam or levee failures is addressed separately. The three seasonal atmospheric events that tend to trigger floods in Pima County are:

- *Tropical Storm Remnants*: Some of the worst flooding tends to occur when the remnants of a hurricane that has been downgraded to a tropical storm or tropical depression enter the State. These events occur infrequently and mostly in the early autumn, and usually bring heavy and intense precipitation over large regions causing severe flooding.
- *Winter Rains*: Winter brings the threat of low intensity; but long duration rains covering large areas that cause extensive flooding and erosion, particularly when combined with snowmelt.
- *Summer Monsoons*: A third atmospheric condition that brings flooding to Arizona is the annual summer monsoon. In mid to late summer the monsoon winds bring humid subtropical air into the State. Solar heating triggers afternoon and evening thunderstorms that can produce extremely intense, short duration bursts of rainfall. The thunderstorm rains are mostly translated into runoff and in some instances, the accumulation of runoff occurs very quickly resulting in a rapidly moving flood wave referred to as a flash flood. Flash floods tend to be very localized and cause significant flooding of local watercourses.

Damaging floods in the County include riverine, sheet, alluvial fan, and local area flooding. Riverine flooding occurs along established watercourses when the bankfull capacity of a watercourse is exceeded by storm runoff or snowmelt and the overbank areas become inundated. Sheet flooding occurs in regionally low areas with little topographic relief that generate floodplains over a mile wide, Alluvial fan flooding is generally located on piedmont areas near the base of the local mountains, such as the Tortolita Fan, that are characterized by multiple, highly unstable flowpaths that can rapidly change during flooding events. Local area flooding is often the result of poorly designed or planned development wherein natural flowpaths are altered, blocked or obliterated, and localized ponding and conveyance problems result. Erosion is also often associated with damages due to flooding.

Another major flood hazard comes as a secondary impact of wildfires in the form of dramatically increased runoff from ordinary rainfall events that occur on newly burned watersheds. Denuding of the vegetative canopy and forest floor vegetation, and development of hydrophobic soils are the primary factors that contribute to the increased runoff. Canopy and floor level brushes and grasses intercept and store a significant volume of rainfall during a storm event. They also add to the overall watershed roughness which generally attenuates the ultimate peak discharges. Soils in a wildfire burn area can be rendered hydrophobic, which according the NRCS is the development of a thin layer of nearly impervious soil at or below the mineral soil surface that is the result of a waxy substance derived from plant material burned during a hot fire. The waxy substance penetrates into the soil as a gas and solidifies after it cools, forming a waxy coating around soil particles. Hydrophobic soils, in combination with a denuded watershed, will significantly increase the runoff potential, turning a routine annual rainfall event into a raging flood with drastically increased potential for soil erosion and mud and debris flows.

History

Flooding is clearly a major hazard in Pima County as shown in Tables 5-2 through 5-4. Pima County has been part of 13 disaster declarations for flooding, with three of those declarations occurring in the past five years. There have been at least 68 other non-declared events of reported flooding incidents that met the thresholds outlined in Section 5.1, 25 of which occurred in the last five years. The following incidents represent examples of major flooding that has impacted the County:

- During August and September of 1983, nearly seven inches of rain fell, saturating the soil around the Tucson metropolitan area. These conditions were exacerbated when a surge of moisture from Tropical Storm Octave, which was located off the central Baja California coast, moved northeast across the area. The result over a four-day period were torrential rains ranging from five to nine inches, causing flooding in Tucson and southeast Arizona. Bridges in the area, including all spanning the Santa Cruz River except one, were damaged or partially washed away. Additional damage occurred along the other watercourses throughout the area. Several buildings fell into Rillito Creek due to bank erosion and extensive damage occurred to agriculture in

Marana. Cost estimates (using 1984 dollars) to repair and mitigate flood damage were estimated at $105.7 million. Four deaths in Eastern Pima County were attributed to the flood.

- In late December 1992 - early January 1993, a series of winter storms produced record breaking precipitation amounts and severe weather across much of Arizona. Heavy rains combined with melting snowpack caused heavy flooding of both local washes and regional rivers within Pima County. Nearly every community and city within the county was impacted by the storms at some level. Most of the heavy damage was associated with the Gila, San Pedro, and Santa Cruz Rivers. According to the USACE Flood Damages Report, the total public and private damages from the 1993 floods were estimated to exceed $12 million in Pima County alone. [14] The flooding prompted a federal disaster declaration (FEMA-977-DR-AZ) for almost the entire state.
- On August 14, 2005 and August 23, 2005 intense heavy rains caused significant damage to public infrastructure throughout Pima County. The severe runoff resulted in damages to numerous roads, traffic lights, water well fields, berms, crossings, and police vehicles. After over an inch of rain fell across a large portion of the Tucson Metro Area, some locations with more than two inches, several roads became flooded, closed, and impassable. In addition to all the flooded roadways, several trailer homes located in the southern portion of the Tucson Metro Area, were flooded and surrounded by rising water. Rescue teams evacuated several people from these homes. Brawley wash was out of its banks and flooding roadways causing them to be impassable. Over $260,000 in damages were estimated (NCDC, 2010)
- In late July and early August 2006, several areas of the state were struck by severe storms and flooding during the period of July 25 to August 4, 2006. Tropical moisture poured into Southeast Arizona, saturating the ground at most locations. As rainfall continued, additional runoff quickly filled rivers and washes, exceeding bank full capacities and flooding homes and businesses as well as nearby roads. Some roadways were washed away due to the strong flood waters. Lots of flash flooding occurred throughout the Tucson Metro Area due to saturated grounds and extremely heavy rainfall. Numerous roads were closed due to flooding throughout the entire Metro Area for many hours. A USGS stream gage was destroyed by flood waters in Rincon Creek. Additionally, there were numerous swift water rescues and car stranded in flooded roadways. It was estimated that nearly 100 vehicles were flooded. Several rivers running through the Tucson Metro Area flooded on July 31, 2006. The Rillito River flooded with water over the cement banks near Dodge Boulevard. Additionally, the Rillito River was over bankfull just east of the Swan Road Bridge. River Road near La Cholla Road was flooding from the Rillito River. Sabino Creek was out of its banks and houses were flooded near Sabino Canyon and Bear Canyon. Below is a listing of some of the damage, but not all, caused by the flooding and an estimate for the cost of repairs:
    - Sabino Canyon Recreation area road and facility damaged, $100,000
    - Forty homes and businesses flooded, $1,200,000
    - One home destroyed due to flooding, $150,000
    - Water main broke near the Mt. Lemmon highway, $20,000
    - Catalina Highway road washed away, $50,000
    - Agricultural irrigation system damaged, $500,000
    - Cement plant flooded, $400,000
    - Gravel pit flooded, $30,000
    - General infrastructure damage, $500,000.

  The flooding prompted a federal disaster declaration (FEMA-1660-DR-AZ) for Gila, Graham, Greenlee, Pima, and Pinal Counties. Total disaster expenditures exceeded $13.6 million (ADEM, 2010; PCRFCD, 2011).
- On February 19, 2008 a state of emergency was declared for Pima County for flooding and damages due to 8.5 inches of precipitation that fell in and around Mt. Lemmon within Pima County in less than a 24-hour period. Damages to roads left residents stranded in their homes, limited access to food and medical assistance and damaged potable water supply lines, which impacted transmission and distribution of potable water to homes. The rainfall and snowmelt created conditions that threatened the health and safety of residents and

[14] US Army Corps of Engineers, Los Angeles District, 1994, *Flood Damage Report – State of Arizona – Floods of 1993*

exceeded the capabilities of Pima County. Several people in Tucson needed to be rescued from flowing washes. Damages were estimated to exceed $770,000 (NCDC, 2010).

- In January 2010, sixteen hikers were trapped on Sabino Canyon Trail at approximately 11 AM on January 21st after the stream rose above its banks, covering low water crossings. The San Simon and Vamori Washes in the Tohono Oodham Nation rose 1-2 feet out of their banks during the evening of January 21st. Several other washes flowed out of their banks, resulting in barricaded roadways near Saguaro National Park East and West, including East Tucson and Avra Valley. A motorist was trapped in the Canada del Oro Wash near Rancho del Lago at approximately 7 AM on January 22nd requiring a swift water rescue. Storm-wide damages were estimated at $300,000 (NCDC, 2011). A presidential disaster was declared (FEMA-1888-DR-AZ) for several counties and Indian tribes in the state including Pima County.
- In July 2010, torrential rainfall across portions of eastern Pima County resulted in numerous reports of flash flooding in the Tucson metro area. Flash flooding was observed on Tanque Verde Creek with a peak depth of 11.69 feet at Tanque Verde Guest Ranch. Approximately 30 homes on Barbary Coast Road, Gold Dust Road, and Kitt Carson were flooded. Numerous swift water rescues were performed in the Tucson metro area, near the county fairgrounds, in the Recon Valley area, and on the Old Spanish Trail in the Hilton Head Ranch area. Damages were estimated to exceed $500,000 (NCDC, 2011)

Numerous other flood related incidents are summarized in the historic hazard database provided in Appendix D.

Probability and Magnitude

For the purposes of this Plan, the probability and magnitude of flood hazards in Pima County jurisdictions are based on the 1% probability floodplains delineated on FEMA Flood Insurance Rate Maps (FIRMs), plus any provisional floodplain delineations used for in-house purposes by participating jurisdictions. FEMA has recently completed a map modification program to update the FIRMs for the County into a digital FIRM (DFIRM) format. The effective date for the new DFIRM maps is June 16, 2011. DFIRM floodplain GIS base files were obtained from FEMA and are the basis for the flood hazard depictions in this Plan.

Two designations of flood hazard are used. Any "A" zone is designated as a HIGH hazard area. MEDIUM flood hazard areas are all "Shaded X" zones. All "A" zones (e.g. – A, A1-99, AE, AH, AO, etc.) represent areas with a 1% (1%) probability of being flooded at a depth of one-foot or greater in any given year. All "Shaded X" zones represent areas with a 0.2% probability of being flooded at a depth of one-foot or greater in any given year. These two storms are often referred to as the 100-year and 500-year storm, respectively.

Maps 1A and 1B show the flood hazard areas for the entire county and the general Tucson Metropolitan Area, respectively. Maps 1C through 1H present flood hazards for each of the incorporated jurisdictions and the Pascua Yaqui Tribe.

Vulnerability

Table 4-11: CPRI results for flood

Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Likely	Catastrophic	12-24 hours	< 6 hours	2.95
Oro Valley	Likely	Catastrophic	< 6 hours	< 1 week	3.45
Pascua Yaqui Tribe	Highly Likely	Critical	6 to 12 hours	< 24 hours	3.35
Sahuarita	Highly Likely	Critical	< 6 hours	< 1 week	3.60
Tucson	Highly Likely	Limited	< 6 hours	< 6 hours	3.10
Unincorporated Pima County	Highly Likely	Critical	< 6 hours	> 6 hours	3.40
				County-wide average CPRI =	**3.31**

Loss Estimations

The estimation of potential exposure to high and medium flood hazards was accomplished by intersecting the human and facility assets with the flood hazard limits depicted on the profile maps. Loss estimates to all facilities located within the high and medium flood hazard areas were made based on the loss estimation tables published by FEMA (FEMA, 2001). Most of the assets located within high hazard flood areas will be subject to three feet or less of flooding.

Using the FEMA tables, it is assumed that all structural assets located within the high hazard areas will have a loss-to-exposure ratio of 0.20 (or 20%). A loss to exposure ratio of 0.05 (5%) is assumed for assets located in the medium hazard areas. Table 5-19 summarizes the critical facility, population, and residential housing unit exposure and loss estimates for the high and medium flood hazards.

In summary, $268.8 million and $21.0 million in critical facility related losses are estimated for high and medium flood hazards, for all the participating jurisdictions in Pima County. An additional $1.09 billion and $146.8 million in high and medium flood losses to 2010 Census residential housing units is estimated for all participating Pima County jurisdictions. Regarding human vulnerability, a total population of 57,745 people, or 5.95% of the total population, is potentially exposed to a high hazard flood event. A total population of 32,361 people, or 3.33% of the total population, is potentially exposed to a medium hazard flood event. Based on the historic record, multiple deaths and injuries are plausible and a substantial portion of the exposed population is subject to displacement depending on the event magnitude.

It is duly noted that the loss and exposure numbers presented above represent a comprehensive evaluation of the County as a whole. It is unlikely that a storm event would occur that would flood all of the delineated high and medium flood hazard areas at the same time. Accordingly, actual event based losses and exposure are likely to be only a fraction of those summarized above. Furthermore, it should be noted that any flood event that exposes assets or population to a medium hazard will also expose assets and populations to the high hazard flood zone. That is, the 100-year floodplain would be entirely inundated during a 500-year flood.

Table 4-12: Pima County exposure and loss estimates due to flooding

Flood Hazard Exposure/Loss	Marana	Oro Valley	Pascua Yaqui Tribe	Sahuarita	South Tucson	Tucson	Unincorporated Pima County	Total
Total Critical Facilities	**272**	**132**	**16**	**76**	**19**	**1,625**	**1,302**	**3,442**
Facilities Exposed to High Hazard	101	7	16	23	0	101	89	337
Percentage of Total Facilities	37.13%	5.30%	100.00%	30.26%	0.00%	6.22%	6.84%	9.79%
Estimated Replacement Cost (x $1,000)	$392,077	$9,248	$311,366	$130,337	$0	$232,604	$270,652	$1,346,284
Estimated Structure Loss (x $,000)	$78,415	$1,850	$62,273	$26,067	$0	$46,521	$54,130	$269,257
Facilities Exposed to Medium Hazard	39	3	0	1	0	70	24	137
Percentage of Total Facilities	14.34%	2.27%	0.00%	1.32%	0.00%	4.31%	1.84%	3.98%
Estimated Replacement Cost (x $1,000)	$97,998	$19,510	$0	$5,300	$0	$205,158	$94,179	$422,146
Estimated Structure Loss (x $1,000)	$4,900	$976	$0	$265	$0	$10,258	$4,709	$21,107
Total Population	**34,622**	**40,557**	**3,675**	**25,142**	**5,593**	**520,368**	**340,692**	**970,648**
Population Exposed to High Hazard	5,311	1,617	3,675	782	3	21,290	25,067	57,745
Percent Exposed	15.34%	3.99%	100.00%	3.11%	0.05%	4.09%	7.36%	5.95%
Population Exposed to Medium Hazard	7,755	621	16	726	0	16,314	6,929	32,361
Percent Exposed	22.40%	1.53%	0.44%	2.89%	0.00%	3.14%	2.03%	3.33%
Total Residential Building Count	**14,573**	**20,053**	**892**	**10,549**	**2,112**	**230,157**	**159,016**	**437,352**
Estimated Replacement Cost (x $1,000)	**$3,629,307**	**$6,831,456**	**$187,175**	**$2,229,431**	**$452,144**	**$40,805,270**	**$42,706,058**	**$96,840,841**
Structures Exposed to High Hazard	2,163	829	892	286	1	10,140	10,361	24,672
Percentage of Total Facilities	14.84%	4.13%	100.00%	2.71%	0.05%	4.41%	6.52%	5.64%
Estimated Replacement Cost (x $1,000)	$538,834	$282,310	$187,175	$60,416	$180	$1,798,046	$2,573,291	$5,440,252
Estimated Structure Loss (x $,000)	$107,767	$56,462	$37,433	$12,083	$36	$359,609	$514,658	$1,088,048
Structures Exposed to Medium Hazard	2,987	313	0	292	0	7,488	2,984	14,064
Percentage of Total Facilities	20.50%	1.56%	0.00%	2.77%	0.00%	3.25%	1.88%	3.22%
Estimated Replacement Cost (x $1,000)	$744,063	$106,706	$0	$61,686	$0	$1,328,512	$695,271	$2,936,238
Estimated Structure Loss (x $1,000)	$37,203	$5,335	$0	$3,084	$0	$66,426	$34,764	$146,812

6.2.4 National Flood Insurance Program Participation

Participation in the NFIP is a key element of any community's local floodplain management and flood mitigation strategy. Pima County and the 6 other incorporated jurisdictions participate in the NFIP. Joining the NFIP requires the adoption of a floodplain management ordinance that requires jurisdictions to follow established minimum standards set forth by FEMA and the State of Arizona, when developing in the floodplain. These standards require that all new buildings and substantial improvements to existing buildings will be protected from damage by the 100-year flood, and that new floodplain development will not aggravate existing flood problems or increase damage to other properties. As a participant in the NFIP, communities also benefit from having Flood Insurance Rate Maps (FIRM) that map identified flood hazard areas and can be used to assess flood hazard risk, regulate construction practices and set flood insurance rates. FIRMs are also an important source of information to educate residents, government officials and the private sector about the likelihood of flooding in their community. Table 6-7 summarizes the NFIP status and statistics for each of the jurisdictions participating in this Plan.

Table 4-13: NFIP statistics as of August 31, 2011

Jurisdiction	Community ID	NFIP Entry Date	Current Effective Map Date	Number of Policies	Amount of Coverage (x $1,000)	Floodplain Management Role
Pima County	040073	2/15/1983	6/16/2011	2,546	$579,900	Managed through PCRFCD
Marana	040118	8/1/1984	6/16/2011	325	$85,073	Provides floodplain management for the town
Oro Valley	040109	12/4/1979	6/16/2011	90	$27,187	Provides floodplain management for the town
Pascua Yaqui Tribe	---	---	---	---	---	Not a Participant in the NFIP
Sahuarita	040137	6/30/1997	6/16/2011	30	$8,450	Provides floodplain management for the town
South Tucson	040075	1/31/1979	6/16/2011	1	$175	City defers floodplain management to PCRFCD
Tucson	040076	8/2/1982	6/16/2011	2,052	$423,498	Provides floodplain management for the city

Source: http://bsa.nfipstat.com/reports/1011.htm (8/31/2011); FEMA Community Status Report in NFIP (2/16/2011)

Repetitive Loss Properties

Repetitive Loss (RL) properties are those NFIP-insured properties that since 1978, have experience multiple flood losses. FEMA tracks RL properties and in particular to identify Severe RL (SRL) properties. RL properties demonstrate a track record of repeated flooding for a certain location and are one element of the vulnerability analysis. RL properties are also important to the NFIP, since structures that flood frequently put a strain on the National Flood Insurance Fund. FEMA records dated January 2010 (provided by ADEM in April 2010) indicate that there are 12 identified RL properties in Pima County and a total of 25 separate claims. Building and content loss payments for those 12 properties totaled approximately $460,000. None of the payments have occurred within the last five years. Table 5-20 summarizes the RL property characteristics by jurisdiction.

Table 4-14: Repetitive loss property statistics for

Jurisdiction	No. of Properties	No. of Properties Mitigated	Total Payments
Oro Valley	1	0	$41,805
Tucson	4	0	$173,829
Unincorporated Pima County	7	3	$243,978

Source: FEMA, 2010

Development Trends

For most Pima County jurisdictions, adequate planning and regulatory tools are in place to regulate future development. Challenges with new growth will include the need for master drainage planning and additional floodplain delineations to identify and map the flood hazards within the growth areas where no mapping currently exists.

Sources

FEMA, 2001, Understanding Your Risks; Identifying Hazards and Estimating Losses, FEMA Document No. 386-2.

U.S. Dept of Commerce, National Climatic Data Center, 2010, Storm Events Database, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

U.S. Army Corps of Engineers, Los Angeles District, 1994, Flood Damage Report, State of Arizona, Floods of 1993.

Profile Maps

Maps 1A and 1B – Flood Hazard Maps for Pima County

Maps 1C through 1H – Jurisdiction Specific Flood Hazard Maps

4.4.6 Hazardous Materials Incidents

Description

The threat of exposure to Hazardous Materials (hazmat) in our modern society is prevalent nationwide and throughout Pima County. Hazmat incidents can occur from either point source spills or from transportation related accidents. In Pima County, the primary areas of risk associated with hazmat incidents are located near or along storage / manufacturing facilities, major roads and rail lines, and pipelines that transport hazardous substances. These substances may be highly toxic, reactive, corrosive, flammable, explosive, radioactive or infectious, with potential to contaminate air, soil, and water resources and pose a serious risk to life, health, environment and property. Hazmat incidents can result in the evacuation of a few people, a specific facility, or an entire neighborhood(s) depending on the size and magnitude of the release and environmental conditions.

The Arizona State Emergency Response Commission (AZSERC), established by Arizona Law (Arizona Revised Statutes-Title 26, Chapter 2, Article 3) is tasked with the implementation of the Emergency Planning and Community Right to Know Act (EPCRA) in Arizona. Local Emergency Planning Committees (LEPC) are appointed by AZSERC, as required by EPCRA, first to design, then to regularly review and update a comprehensive emergency plan for an emergency planning district. There are 15 LEPC's in Arizona - one in each county.

State statutes and Sections 311 and 312 of EPCRA set forth hazardous chemical storage reporting requirements and thresholds for facilities possessing hazardous materials. The legislation requires that facilities storing or producing hazardous materials in quantities that exceed a defined Threshold Planning Quantity (TPQ), submit an annual chemical inventory report (Tier II Hazardous Chemical Inventory Form) to AZSERC, the appropriate LEPC, and local fire department, by March 1 of each year. Facilities holding an Extremely Hazardous Substance (EHS) at quantities exceeding the Threshold Planning Quantities (TPQ) must provide the notifications as well as a representative to participate in the county emergency planning process.

For the purposes of this Plan, the Planning Team chose to focus only on those hazmat facilities and chemicals that are classified by the Environmental Protection Agency (EPA) as extremely hazardous substances (EHS) Typical EHS materials transported and stored routinely in the county include chlorine gas, sulphuric acid, and hydrogen flouride.

History

According to the National Response Commission database, there are at least 42 reported incidents of hazmat releases that have occurred since 1991 within Pima County that involved at least one injury/fatality or some amount of property damage. Many of the incidents were tied to vehicular accidents involving passenger vehicles, semi tractor trailers, and/or railroad cars. The following incidents represent examples of hazardous materials incidents that have occurred in Pima County:

- In December of 1997, a tractor trailer rig carrying 8,000 gallons of ethylene glycol rolled over spilling approximately half of the load. One injury was reported (NRC, 2011).
- In March of 1998, a 55 gallon drum of molybdenum pentachloride fell off the back of a truck and was struck by 2 passenger vehicles releasing approximately 7 cubic feet of the material. One injury was reported (NRC, 2011).
- In June of 1998, a half-inch natural gas distribution line was ruptured at a mobile home and ignited into an open natural gas flame. The mobile home was destroyed with damages estimated at $100,000 (NRC, 2011).
- In April of 2005, a railcar released an unknown amount of sulphuric acid causing a railroad employee to become sick. The release was due to a faulty gasket (NRC, 2011)
- In July of 2006, four locomotives and six railcars carrying hydrochloric acid derailed. The locomotives remained upright, but the railcars all turned over on their sides and hydrochloric acid was reported as leaking. One injury was reported (NRC, 2011).
- In September of 2009, 500 gallons of asphalt was spilled from a tanker truck and entered a storm drain that ultimately drains to the Santa Cruz River. Approximately $2,000 in damages was reported (NRC, 2011).

Probability and Magnitude

There are no known probability statistics regarding hazmat incidents for Pima County.

Typically, the magnitude of impact from a hazmat incident can be projected by using models such as ALOHA and CAMEO with assumed incident characteristics such as chemical type and source amount, spill location and amount, release time and rate, surface type, temperature, humidity, wind direction and speed, chemical stability factors. Those modeling efforts, however, are beyond the scope of this Plan.

For the purpose of this Plan, the Planning Team chose to establish two (2) hazard classifications, high and medium, for profiling EHS hazards. High hazard exposure areas are assumed to be located within a one-mile radius or offset of any Tier II EHS facility, roadway and railway transportation corridor where EHS materials are known to be stored or transported on a somewhat regular basis. Similarly, the medium hazard exposure areas are assumed to be located within a second one-mile wide band that is offset from the High hazard area. All other areas are considered to be Low hazard.

Maps 2A and 2B show the hazmat hazard areas for the entire County and Tucson Metropolitan area. Maps 2C through 2H show the hazmat hazard areas for each jurisdiction.

Vulnerability

Table 4-15: CPRI results for HazMat

Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Possible	Catastrophic	< 6 hours	< 24 hours	2.90
Oro Valley	Possible	Critical	< 6 hours	< 24 hours	2.60
Pascua Yaqui Tribe	Possible	Critical	6 to 12 hours	< 24 hours	2.60
Sahuarita	Likely	Catastrophic	< 6 hours	< 1 week	3.45
Tucson	Possible	Limited	< 6 hours	< 24 hours	2.30
Unincorporated Pima County	Highly Likely	Limited	< 6 hours	< 6 hours	3.10
				County-wide average CPRI =	**2.83**

Loss Estimations

The estimation of potential exposure to high and medium hazmat hazards was accomplished by intersecting the human and critical facility assets with the hazmat hazard limits depicted on Maps 2A through 2H. Table 5-23 summarizes the critical facility, population, and residential housing unit exposure to the high and medium hazmay hazards. No losses are estimated for this hazard.

In summary, $11.2 billion and $366.6 million in critical facilities are exposed to high and medium hazmat hazards, for all the participating jurisdictions in Pima County. An additional $94.4 billion and $1.94 billion in county-wide Census 2010 residential housing units are estimated to be exposed to high and medium hazmat hazards. Regarding human vulnerability, a total population of 945,139 people, or 97.4% of the total county-wide population, is potentially exposed to a high hazard hazmat event. A total population of 20,977 people, or 2.2% of the total population, is potentially exposed to a medium hazard hazmat event. It is recognized that EHS incidents typically occur in a single localized area and do not impact an entire county or community at one time. These numbers are intended to represent the collective community or county-wide exposure. Actual losses for an individual incident are likely to be only a fraction of the numbers presented here. Because of the nature of this hazard, structural damage is highly unlikely and decontamination costs related to replacements cost would only be a small fraction.

Table 4-16: Pima County exposure estimates due to Hazmat

HAZMAT HAZARD EXPOSURE / LOSS	Marana	Oro Valley	Pascua Yaqui Tribe	Sahuarita	South Tucson	Tucson	Unincorporated Pima County	Total
Total Critical Facilities	**272**	**132**	**16**	**76**	**19**	**1,625**	**1,302**	**3,442**
Facilities Exposed to High Hazard	269	131	4	76	19	1,603	1,119	3,221
Percentage of Total Facilities	98.90%	99.24%	25.00%	100.00%	100.00%	98.65%	85.94%	93.58%
Estimated Replacement Cost (x $1,000)	$764,814	$438,755	$222,516	$278,952	$48,227	$6,462,354	$3,022,273	$11,237,892
Estimated Structure Loss (x $,000)	$0	$0	$0	$0	$0	$0	$0	$0
Facilities Exposed to Medium Hazard	3	0	12	0	0	17	85	117
Percentage of Total Facilities	1.10%	0.00%	75.00%	0.00%	0.00%	1.05%	6.53%	3.40%
Estimated Replacement Cost (x $1,000)	$285	$0	$88,850	$0	$0	$4,985	$272,522	$366,642
Estimated Structure Loss (x $1,000)	$0	$0	$0	$0	$0	$0	$0	$0
Total Population	**34,622**	**40,557**	**3,675**	**25,142**	**5,593**	**520,368**	**340,692**	**970,648**
Population Exposed to High Hazard	34,160	40,163	154	22,193	5,593	520,130	322,746	945,139
Percent Exposed	98.67%	99.03%	4.19%	88.27%	100.00%	99.95%	94.73%	97.37%
Population Exposed to Medium Hazard	394	361	3,521	2,595	6	236	13,864	20,977
Percent Exposed	1.14%	0.89%	95.81%	10.32%	0.11%	0.05%	4.07%	2.16%
Total Residential Building Count	**14,573**	**20,053**	**892**	**10,549**	**2,112**	**230,157**	**159,016**	**437,352**
Estimated Replacement Cost (x $1,000)	**$3,629,307**	**$6,831,456**	**$187,175**	**$2,229,431**	**$452,144**	**$40,805,270**	**$42,706,058**	**$96,840,841**
Structures Exposed to High Hazard	14,257	19,767	50	8,864	2,112	230,081	151,124	426,255
Percentage of Total Facilities	97.83%	98.57%	5.61%	84.03%	100.00%	99.97%	95.04%	97.46%
Estimated Replacement Cost (x $1,000)	$3,550,650	$6,735,120	$7,615	$1,873,283	$452,144	$40,791,306	$40,999,837	$94,409,955
Estimated Structure Loss (x $,000)	$0	$0	$0	$0	$0	$0	$0	$0
Structures Exposed to Medium Hazard	255	263	842	1,440	0	76	5,912	8,788
Percentage of Total Facilities	1.75%	1.31%	94.39%	13.65%	0.00%	0.03%	3.72%	2.01%
Estimated Replacement Cost (x $1,000)	$63,407	$88,587	$179,560	$304,256	$0	$13,964	$1,295,202	$1,944,976
Estimated Structure Loss (x $1,000)	$0	$0	$0	$0	$0	$0	$0	$0

Development Trends

As the vulnerability analysis indicates, nearly 100% of Pima County population and infrastructure is exposed to some level of EHS threat. That exposure will only worsen as development increases. It may be advantageous to pursue designating certain roadways as EHS corridors to limit the exposure, and establishing buffer zones along corridors known to be frequent EHS transport routes. Development of high-density population land uses such as schools, nursing homes, apartment complexes, etc., should be discouraged within these zones.

EHS facilities that have potential for critical or catastrophic hazmat releases should be located on flat topography and take care to protect against negative climate and microclimate conditions; utilize shading from excessive sun in warm climate and/or other best management practices.

Sources

Arizona Division of Emergency Management, 2010, State of Arizona Multi-Hazard Mitigation Plan.

National Response Center, 2011, database obtained from website. http://www.nrc.uscg.mil/nrchp.html

U.S. Department of Transportation, 1996, North American Emergency Response Guidebook

Maps

Maps 2A and 2B – County-Wide and Tucson Metro Area HAZMAT Hazard Maps

Maps 2C through 2H– Jurisdiction Specific HAZMAT Hazard Maps

4.4.6 Levee Failure

Description

FEMA defines levees as man-made structures, usually earthen embankments that are designed and constructed in accordance with sound engineering practices to contain, control or divert the flow of water so as to provide protection from temporary flooding (FEMA, 2009). National flood policy now recognizes the term "levee" to mean only those structures which were designed and constructed according to sound engineering practices, have up to date inspection records and current maintenance plans, and have been certified as to their technical soundness by a professional engineer. FEMA has classified all other structures that impound, divert, and/or otherwise impede the flow of runoff as "non-levee embankments". In Pima County, these "non-levee embankments" might be comprised of features such as roadway and railway embankments, canals, irrigation ditches and drains, and agricultural dikes. Currently there is no State or Federal Levee Safety Program and no official state or federal levee inventory. It is anticipated that FEMA will institute a National Levee Safety Program in the near future.

By design, a levee and many non-levee embankments increase the conveyance capacity of a watercourse by artificially creating a deeper channel through embankments that extend above the natural overbank elevation. Upon failure, floodwaters will return to the natural overbank areas. FEMA urges communities to recognize that all areas downstream of levees and embankments are at some risk of flooding and that there are no guarantees that a levee or embankment will not fail or breach if a large quantity of water collects upstream.

Mechanisms for levee failure may include seismic events, extreme wave action, leakage and piping, overtopping, and material fatigue. Failure by overtopping could occur due to an inadequate design capacity, sediment deposition and vegetation growth in the channel, subsidence, and/or runoff that exceeds the design recurrence interval of the levee. Failure by piping could be due to embankment cracking, fissures, animal boroughs, embankment settling, or vegetal root penetrations.

History

Levees (certified or not) have been used in Pima County for over a hundred years to protect communities and agricultural assets from flooding, as well as to facilitate the delivery and removal of irrigation water. These levees range from simple earthen embankments pushed up by small equipment to large engineered embankments lining both sides of a watercourse. The structural integrity of levees with regard to flood protection and policy has been discussed at a national level since the early 1980s but was elevated to a high priority after the collapse and breach of the New Orleans levees after Hurricane Katrina in 2005.

There are no documented failures of certified levees within Pima County. Non-levee embankment failures, however, occur on a regular basis and the risk posed by the many uncertified embankments in the county's inventory is great.

Probability and Magnitude

There are varied probability or magnitude criteria regarding levee failure due to variability in levee design, ownership and maintenance. For flood protection credit under the NFIP, FEMA has established certain deterministic design criteria that are based on the 1% (100-year) storm event and a corresponding minimum freeboard requirement. Federally constructed levees are usually designed for larger, more infrequent events that equate to 250 to 500 year events plus freeboard. Recent recertification procedures proposed by U.S. Army Corps of Engineers, require that a certifiable levee have at least a 90% assurance of providing protection from overtopping by the 1% chance exceedance flood for all reaches of a levee system with a design freeboard height of at least three feet. For levees with less than three feet of design freeboard, the assurance is increased to 95%, and no certification will be made for levees with less than two feet of freeboard unless approved via a waver process. This assurance is only for containment (overtopping failure) and does not include probability of failure by any other mode (USACE, 2007). All of the FEMA certified levees within Pima County are designed to safely convey the 100-year event, with a factor of safety provided by a minimum additional freeboard of 3 feet.

The recent DFIRM data provided by FEMA delineates recognized levees within the county and provides a special flood zone designation of "Shaded Zone X – Protected by Levee" for areas that are protected by a levee, but otherwise subject to 100-year flooding should the levee fail or be removed. For the purpose of this Plan, the Planning Team chose to identify the special levee protection zones as the high hazard areas of levee failure. It is recognized that this initial hazard area assignment will require further analysis to account for the failure impact areas of the many non levee embankments.

The currently identified high hazard levee failure zones are indicated on Maps 3A – 3D, which depict the county as a whole, and the incorporated limits of Marana, Oro Valley, and Tucson. No other jurisdictions have levees or high hazard zones identified within their incorporated or reservation boundaries.

Vulnerability

Table 4-17: CPRI results for levee failure

Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Possible	Catastrophic	6 to 12 hours	< 1 week	2.85
Oro Valley	Unlikely	Catastrophic	12 to 24 hours	< 1 week	2.25
Pascua Yaqui Tribe	Unlikely	Negligible	> 24 hours	< 6 hours	1.00
Sahuarita	Unlikely	Negligible	> 24 hours	< 6 hours	1.00
Tucson	Unlikely	Negligible	> 24 hours	< 6 hours	1.00
Unincorporated Pima County	Possible	Negligible	< 6 hours	< 6 hours	1.90
				County-wide average CPRI =	**1.67**

Loss Estimations

There are no commonly accepted methods for estimating potential levee related losses. Many variables including storm size and duration, as well as location, size, speed, and timing at which a levee breach forms, all contribute to the potential for human and economic losses. Accordingly, no estimates of loss are made in this Plan. Potential exposure of human and facility assets to the high hazard levee failure areas will be estimated instead. Table 5-26 summarizes the critical facility, population, and residential housing unit exposure to high levee failure hazards.

In summary, $66.6 million in county-wide critical facilities are exposed to a high hazard levee failure. An additional $135.5 million in county-wide 2010 Census residential housing units are estimated to be exposed to a high hazard levee failure. Regarding human vulnerability, a total population of 2,777 people, or 1.54% of the total county-wide population, is potentially exposed to a high hazard levee failure event. Should a levee structure fail suddenly, it is plausible that death and injury might occur. It can also be expected that a substantial portion of the exposed population is subject to displacement depending on the event magnitude.

It is duly noted that the exposure numbers presented above represent a comprehensive evaluation of the County as a whole. It is unlikely that a storm event would occur that would fail all of the levees at the same time. Accordingly, actual event based losses and exposure are likely to be only a fraction of those summarized above.

Development Trend Analysis

With the new focus on residual downstream risk for the land-side of levees and a general refocusing of national levee regulation and policy it is likely that new and old developments in these areas will need to be revisited to determine if additional measures are necessary for adequate flood protection. Many structures located downstream of non-levee embankments are being re-mapped into Special Flood Hazard Zones. New developments should be evaluated to determine if sufficient protection is proposed to mitigate damages should the upstream structure fail.

Table 4-18: Pima County exposure estimates due to levee failure

LEVEE FAILURE HAZARD EXPOSURE / LOSS	Marana	Oro Valley	Pascua Yaqui Tribe	Sahuarita	South Tucson	Tucson	Unincorporated Pima County	Total
Total Critical Facilities	**272**	**132**	**16**	**76**	**19**	**1,625**	**1,302**	**3,442**
Facilities Exposed to High Hazard	4	3	0	0	0	11	7	25
Percentage of Total Facilities	1.47%	2.27%	0.00%	0.00%	0.00%	0.68%	0.54%	0.73%
Estimated Replacement Cost (x $1,000)	$2,472	$19,510	$0	$0	$0	$855	$66,974	$89,811
Estimated Structure Loss (x $,000)	$0	$0	$0	$0	$0	$0	$0	$0
Total Population	**34,622**	**40,557**	**3,675**	**25,142**	**5,593**	**520,368**	**340,692**	**970,648**
Population Exposed to High Hazard	371	548	0	0	0	41	1,358	2,317
Percent Exposed	1.07%	1.35%	0.00%	0.00%	0.00%	0.01%	0.40%	0.24%
Total Residential Building Count	**14,573**	**20,053**	**892**	**10,549**	**2,112**	**230,157**	**159,016**	**437,352**
Estimated Replacement Cost (x $1,000)	**$3,629,307**	**$6,831,456**	**$187,175**	**$2,229,431**	**$452,144**	**$40,805,270**	**$42,706,058**	**$96,840,841**
Structures Exposed to High Hazard	132	278	0	0	0	10	509	929
Percentage of Total Facilities	0.91%	1.39%	0.00%	0.00%	0.00%	0.00%	0.32%	0.21%
Estimated Replacement Cost (x $1,000)	$32,835	$94,650	$0	$0	$0	$1,847	$112,868	$242,200
Estimated Structure Loss (x $,000)	$0	$0	$0	$0	$0	$0	$0	$0

Sources

Arizona Division of Emergency Management, 2010, State of Arizona Multi-Hazard Mitigation Plan

FEMA, 2001, Understanding Your Risks; Identifying Hazards and Estimating Losses, FEMA Document No. 386-2.

FEMA, 2009, http://www.fema.gov/plan/prevent/fhm/lv_intro.shtm#3

USACE, 2007, *Certification of Levee Systems for the National Flood Insurance Program (NFIP) – DRAFT*, ETL 1110-2-570.

Maps

Map 3A – County-wide Levee Failure Hazard Map

Maps 3B through 3D – Levee Failure Hazard Maps for Marana, Oro Valley, and Tucson.

4.4.8 Severe Wind

Description

The hazard of severe wind encompasses all climatic events that produce damaging winds. For Pima County, severe winds usually result from either extreme pressure gradients that usually occur in the spring and early summer months, or from thunderstorms. Thunderstorms can occur year-round and are usually associated with cold fronts in the winter, monsoon activity in the summer, and tropical storms in the late summer or early fall.

Three types of damaging wind related features typically accompany a thunderstorm; 1) downbursts, 2) straight line winds, and infrequently, 3) tornadoes.

Downbursts are columns of air moving rapidly downward through a thunderstorm. When the air reaches the ground, it spreads out in all directions, creating horizontal wind gusts of 80 mph or higher. Downburst winds have been measured as high as 140 mph. Some of the air curls back upward with the potential to generate a new thunderstorm cell. Downbursts are called macrobursts when the diameter is greater than 2.5 miles, and microbursts when the diameter is 2.5 miles or less. They can be either dry or wet downbursts, where the wet downburst contains precipitation that continues all the way down to the ground, while the precipitation in a dry downburst evaporates on the way to the ground, decreasing the air temperature and increasing the air speed. In a microburst the wind speeds are highest near the location where the downdraft reached the surface, and are reduced as they move outward due to the friction of objects at the surface. Typical damage from downbursts includes uprooted trees, downed power lines, mobile homes knocked off their foundations, block walls and fences blown down, and porches and awnings blown off homes.

Straight line winds are developed similar to downbursts, but are usually sustained for greater periods as a thunderstorm reaches the mature stage, traveling parallel to the ground surface at speeds of 75 mph or higher. These winds are frequently responsible for generating dust storms and sand storms, reducing visibility and creating hazardous driving conditions.

A tornado is a rapidly rotating funnel (or vortex) of air that extends toward the ground from a cumulonimbus cloud. Most funnel clouds do not touch the ground, but when the lower tip of the funnel cloud touches the earth it becomes a tornado and can cause extensive damage. For Pima County, tornadoes are the least common severe wind.

History

Pima County has had one state / federal declaration involving severe winds. The combined economic loss of those events is over $29.2 million to property and agriculture in the last 50 years, and there were at least 3 deaths and 103 injuries, with most being related to dust storm related accidents on Interstate 10. In reality, severe wind events occur on a significantly more frequent basis throughout the county, but do not always have reported damages associated with every event. For example, a total of 119 thunderstorm related and 1 tornado related severe wind events were noted in the NCDC database for period of April 2006 through April 2011. However, not all of those events had reports of damages, fatalities, or injuries associated with them. The following are examples of documented past events that have occurred in the last five years:

- In July 2006, a thunderstorm over eastern portions of the Tucson Metro area produced strong winds which downed a 125 foot tall tree onto an apartment complex on Speedway Boulevard near Kolb Road. There were no injuries but eight families were evacuated so repairs could be made. Damage was estimated at the time to be about $350,000 (NCDC, 2011).
- In October 2006, a nearly stationary F0 tornado caused damage to a trailer, parked at a residence on Avra Valley Road in Marana, AZ, by blowing it onto its side. Also, a few homes near the intersection of West Avra Valley Road and North Anway Road experienced minor damage. Damages were estimated at $13,000 (NCDC, 2011)
- In July 2007, approximately 100 trees were uprooted and knocked down at Oro Valley Country Club on Greenock Road due to a wet microburst. An additional 30 trees were uprooted at a nearby shopping plaza at Oracle Road and 1st Avenue. The uprooted trees caused roof damage to several houses. The storms also blew off part of a roof at the Blue Moon stables in Oro Valley. Damages were estimated to exceed $150,000. (NCDC, 2011).
- In July 2007, two mobile homes were destroyed and a traditional home partially destroyed in the Ventana Section of the Tucson Foothills. There were two uprooted trees at Grant Road and Kolb Road in Tucson and

an estimated 60 mph gust due to thunderstorms in Tucson. A roof also collapsed at a furniture store near 22nd street and Wilmot road. In addition, these thunderstorms knocked down about 20 power poles near Palo Verde Road and Irvington Road. There were 18,000 customers without power in the Tucson area. Damages were estimated to exceed $225,000 (NCDC, 2011).

- In August 2008, extensive wind damage occurred on the north side of Tucson due to a microburst. Reported damages included 28 power poles knocked down (including a dozen at River Road and Dodge Blvd) resulting in 35,000 customers without power, some for an extended period as much as two days. Damage was also reported at the Jewish Community Center near River Road and Alvernon Way. There was also roof damage to numerous businesses and hundreds of trees knocked down. Damages were estimated to exceed $2.5 million. (NCDC, 2011).
- In June 2009, severe thunderstorm downburst winds caused significant damage at Three Points. Several mobile homes and nearby sheds were either heavily damaged or destroyed. A more substantial brick veneer building was also damaged, with varying degrees of roof damage reported to several homes in Three Points. Several large trees were uprooted completely. Winds from this severe thunderstorm were estimated to be near 85 mph. Three Points Fire reported one injury was received by flying glass, after winds blew out a house window. Damages were estimated to exceed $150,000. (NCDC, 2011).
- In August 2010, local broadcast media reported up to 3 dozen trees damaged or uprooted in Rancho Vistoso neighborhood. A few ceramic roof tiles were also blown off homes. In addition, a NWS Employee reported several trees down in Dove Mountain with one tree leaning up against a home. There was only slight tile damage to the home. Also, local broadcast media reported trees and power lines down in Marana at Interstate 10 and Marana/Trico Road as well as a roof ripped off a mobile home. The Marana Airport also sustained damage. Two small airplanes were ripped from their tie down chains and were flipped over while another plane was blown into a field. A large hangar door was blown off its tracks and a few other hangars also sustained light damage. In the same area, several power poles and lines were downed on Twin Peaks Road east of N. Sandario Road. Damages were estimated to exceed $100,000. (NCDC, 2011).

Map 4 is a depiction of historic locations and severity of severe wind events impacting Pima County over the period of 1952 to 2010. Data points are plotted based on coordinate information provided in the NCDC database and are not intended to represent the actual extent of impact for the particular event.

Probability and Magnitude

Most severe wind events are associated with thunderstorms as previously mentioned. The probability of a severe thunderstorm occurring with high velocity winds increases as the average duration and number of thunderstorm events increases. The average annual duration of thunderstorms in Pima County ranges from 80 - 90 minutes and is among the longest in the nation (ADEM, 2004). According to the NCDC database records for the past five years, Pima County averages about 25 severe wind events a year. For that same five year time period, approximately $5.8 million in damages were estimated.

The NWS issues a severe thunderstorm watch when conditions are favorable for the development of severe thunderstorms. The local NWS office considers a thunderstorm severe if it produces hail at least 3/4-inch in diameter, wind of 58 mph or higher, or tornadoes. When a watch is issued for a region, residents are encouraged to continue normal activities but should remain alert for signs of approaching storms, and continue to listen for weather forecasts and statements from the local NWS office. When a severe thunderstorm has been detected by weather radar or one has been reported by trained storm spotters, the local NWS office will issue a severe thunderstorm warning. A severe thunderstorm warning is an urgent message to the affected counties that a severe thunderstorm is imminent. The warning time provided by a severe thunderstorm watch may be on the order of hours, while a severe thunderstorm warning typically provides an hour or less warning time.

Based on the historic record, the probability of tornados occurring in Pima County is limited. Tornado damage severity is measured by the Fujita Tornado Scale, which assigns a numerical value of 0 to 5 based on wind speeds, as shown in Table 5-28, with the letter F preceding the number (e.g., FO, F1, F2). Most tornadoes last less than 30 minutes, but some last for over an hour. The path of a tornado can range from a few hundred feet to miles. The width of a tornado may range from tens of yards to more than a quarter of a mile.

Table 4-19: Fujita Tornado Scale

Category	Wind Speed	Description of Damage
F0	40-72 mph	Light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
F1	73-112 mph	Moderate damage. The lower limit is the beginning of hurricane speed. Roof surfaces peeled off; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
F2	113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
F3	158-206 mph	Severe damage. Roofs and some walls torn off well constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.
F4	207-260 mph	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	261-318 mph	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized missiles fly through the air in excess of 100-yards; trees debarked.

Source: FEMA, 1997.

Vulnerability

Table 4-20: CPRI results for severe wind

Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Possible	Critical	6 to 12 hours	< 24 hours	2.45
Oro Valley	Likely	Limited	< 6 hours	< 6 hours	2.65
Pascua Yaqui Tribe	Likely	Limited	6 to 12 hours	< 6 hours	2.50
Sahuarita	Highly Likely	Limited	< 6 hours	< 24 hours	3.20
Tucson	Highly Likely	Limited	6 to 12 hours	< 24 hours	3.05
Unincorporated Pima County	Highly Likely	Critical	< 6 hours	< 24 hours	3.50
				County-wide average CPRI =	**2.89**

Loss Estimations

The entire County is assumed to be equally exposed to the damage risks associated with severe winds. Typically, incidents are fairly localized and damages associated with individual events are relatively small. Based on the historic record over the last five years, it is feasible to expect average annual losses of $1.0 to $1.5 million (county-wide). It is difficult to estimate losses for individual jurisdictions within the County due to the lack of discrete data.

Development Trend Analysis

Future development will expand the exposure of life and property to the damaging effects of severe wind events. Enforcement and/or implementation of modern building codes to regulate new developments in conjunction with public education on how to respond to severe wind conditions are arguably the best way to mitigate against losses.

Sources

Arizona Division of Emergency Management, 2004, State of Arizona All Hazard Mitigation Plan.

Arizona Division of Emergency Management, 2010, State of Arizona Multi-Hazard Mitigation Plan, 2010 Update.

Changnon, Jr. S.,1988, *Climatology of Thunder Events in the Conterminous U.S., Part I: Temporal Aspects* and *Part II: Spatial Aspects*, Journal of Climate, Vol. 1, No. 4, pp. 389-405.

U.S. Dept of Commerce, National Climatic Data Center, 2011, Storm Events Database, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Maps

Map 4 – Severe Wind Event Map

4.4.9 Subsidence

Description

Subsidence occurs when the original land surface elevation drops due to changes in the subsurface. Causes of subsidence include, but are not limited to, removal of fluids (water, oil, gas, etc.), mine collapse, and hydrocompaction. Of these causes, hydrocompaction and mine collapse tend to be localized events, while fluid removal may occur either locally or regionally. The main cause for subsidence in Pima County is excessive groundwater withdrawal, wherein the volume of water withdrawn exceeds the natural recharge. Once an area has subsided, it is likely the ground elevation will not rise again due to consolidation of the soils, even if the pumped groundwater is replaced.

Subsidence causes regional drainage patterns to change. Impacts include unexpected flooding, storm drain backwater, reversal of channel and sewer system drainage patterns, and damages to infrastructure both in the subsurface (water, sewer, electric lines, well casings, etc.) and surface (roads, canals, drainages, surveyed benchmarks, etc.). Subsidence also causes fissures to develop along tension cracks that form at the edge of the subsiding area and over shallow pinnacles of bedrock.

Land-use areas that are predominantly agricultural tend to experience the most intense subsidence due to groundwater based irrigation practices. Subsidence is not, however, restricted to only rural areas since exponential population growth also places great demands on groundwater.

History

In an article published in the University of Arizona Water Resources Research Center's *Arroyo* (Gelt, 2002), the following observations were made regarding subsidence in the Tucson Basin:

"A recent study indicated that the subsidence rate in parts of the Tucson basin is increasing. If this, in fact, is occurring, then the event might presage a development expected by some geologists; i.e., subsidence as a growing problem in urban areas in Arizona.

Subsidence has been detected in certain urban areas of the state. It has occurred for example in sections of the Phoenix metropolitan area. And even some of the subsidence in the Casa Grande area may be attributable to urban groundwater use. That subsidence is occurring in Tucson has been recognized for a period of time. The concern now is that the Tucson subsidence rate is increasing. The damage and disruption to be expected from extensive subsidence occurring in a large metropolitan area thus gain importance as an issue.

Research has demonstrated that between 1947 and 1981, the Tucson basin ground surface dropped 3 millimeters (twelve-hundreds of an inch) for every meter of water loss. Recent research conducted by John S. Sumner, University of Arizona professor emeritus of geosciences, and graduate student Michael A. Hatch indicates that between 1987 and 1991 the surface of the Tucson Basin dropped an average of 24 millimeters (about an inch) for every drop of one meter in the water table, with subsidence ranging from half an inch to 2 inches. The water table under Tucson has been dropping about one meter or over three feet a year since the 1940s.

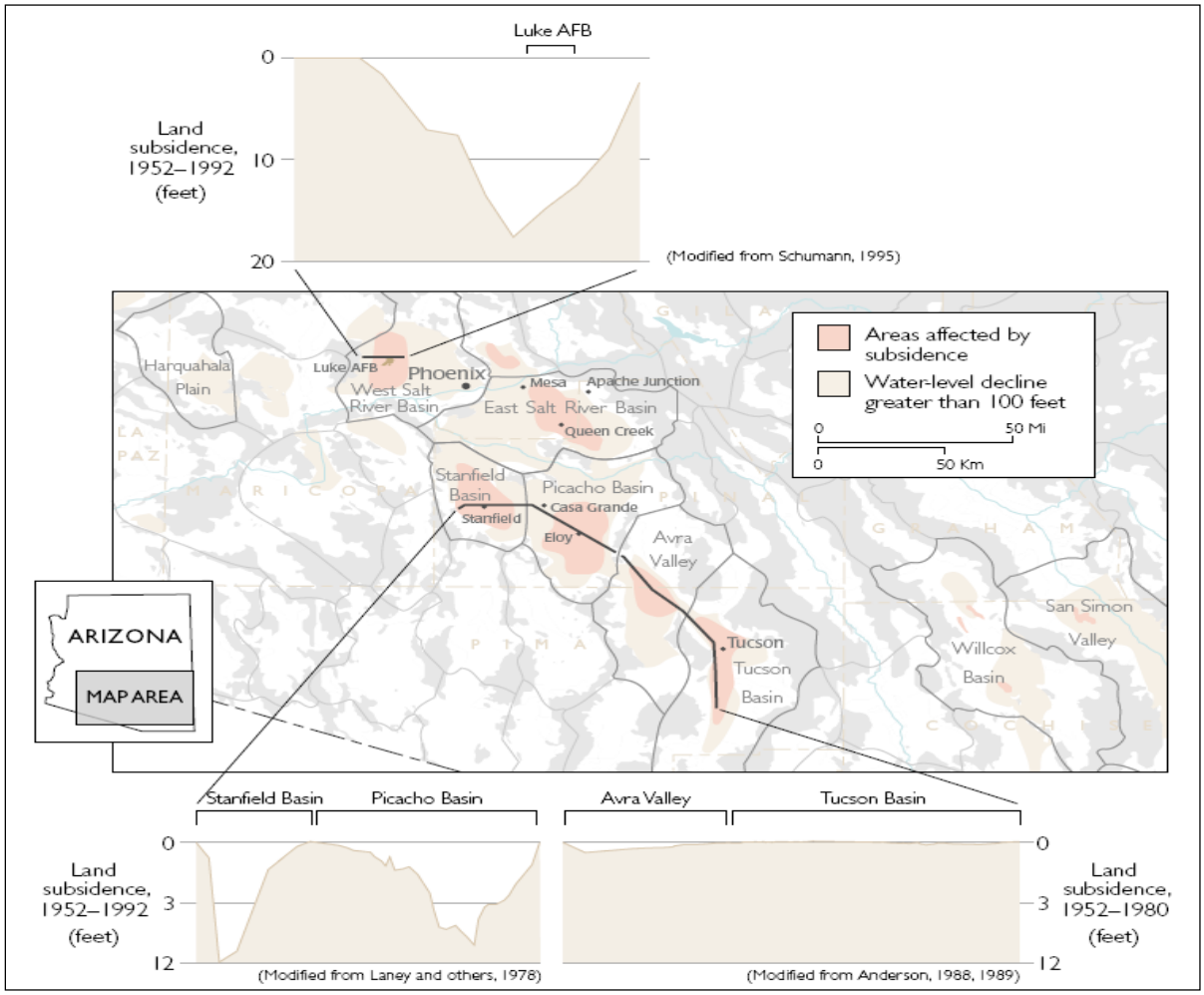
Hatch points out that if the average subsidence rate in the Tucson basin of a half-inch to two inches per year continues for the next 30 years, much of the basin will settle about a foot during that time. Some areas might even subside up to four feet.

Sumner and Hatch further suggest that the subsidence rate may be increasing because of a loss of elasticity within the basin, the result of various subsurface developments. Because of the consistent groundwater pumping within the area, the water table might have dropped below the clay layers. Without the water, the clay particles are compressed more tightly by the weight of the overlying rocks, and their water storage capacity is thus permanently reduced. Subsidence would then be inelastic because the sinking of the ground surface is permanent. Recharge would not reverse the process."

Active subsidence has been occurring in certain areas of Pima County for over 60 years and is primarily due to groundwater overdraft. By 1980 ground-water levels in the southern areas of the state had declined at least 100 feet in many locations and between 300 and 500 feet in some specific areas (Carpenter, 1999). Figure 5-10 illustrates profile estimates of ground subsidence in several south-central Arizona locations.

In a study performed by the USGS (Carruth et al, 2008) for the Tucson Active Management Area (TAMA), estimates of subsidence for the 18 year period of 1987 - 2005 indicated a range of 0 - 5 inches of subsidence has occurred in the Tucson Basin area. Figure 5-11 is an excerpt from that report showing the mapped areas of subsidence.

There are no documented losses directly attributed to subsidence in Pima County.



Source: USGS (Carpenter, 1999)

Map 4-5: South-Central Arizona Land Subsidence Profiles

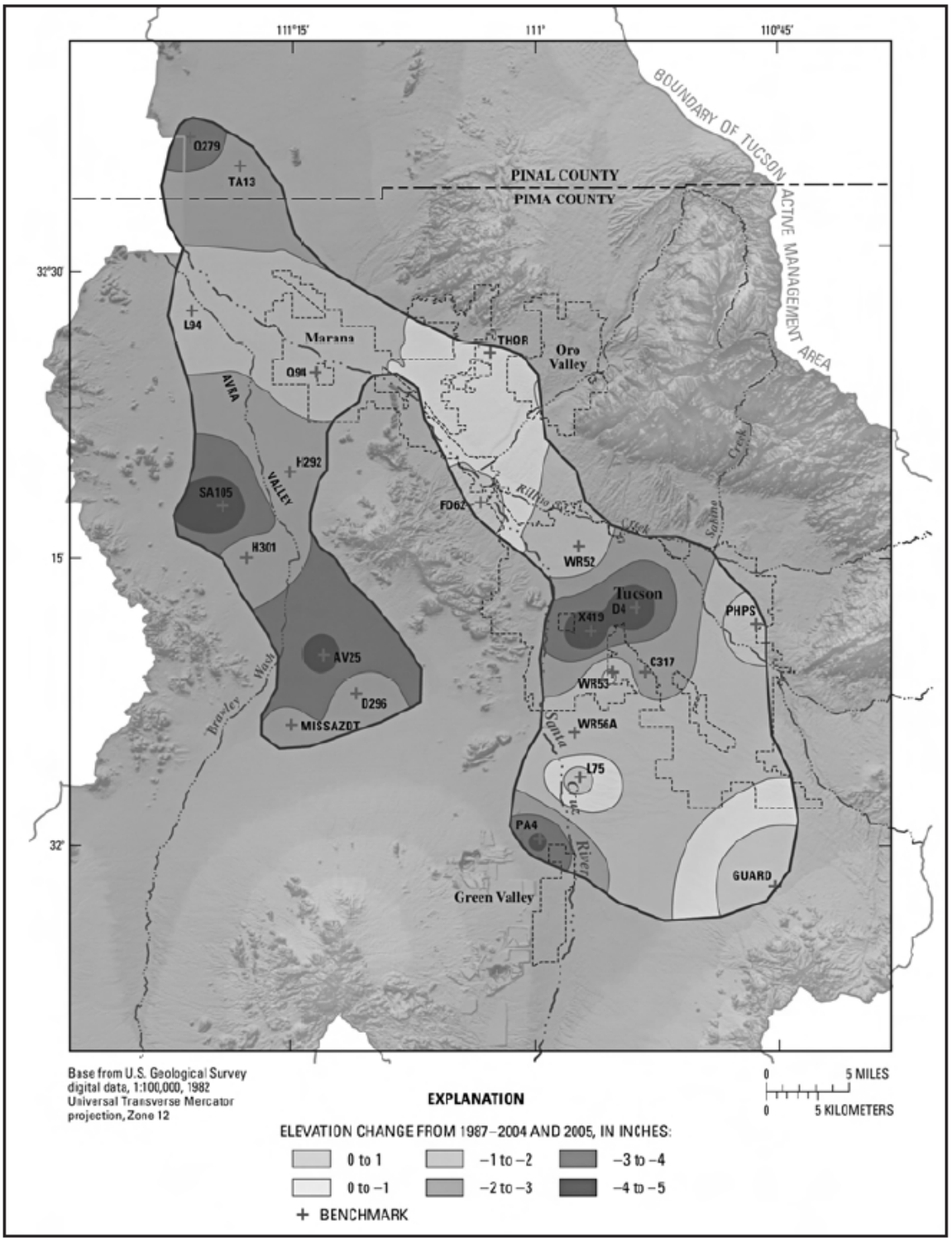


Figure 4. Land-surface elevation change in the Tucson Active Management Area, south-central Arizona, from 1987 to 2004.

Source: USGS (Carruth et al, 2008)

Map 4-6: Tucson Active Management Area Subsidence

Probability and Magnitude

There are no statistical probability estimates for subsidence. The magnitude of land subsidence has been detected over the years using surveying techniques such as differential leveling and high accuracy Global Positioning System (GPS) surveying. In the early 1990's, scientists began to use a satellite based technology called Synthetic Aperture Radar (SAR) and interferometric processing (InSAR) to detect land surface elevation changes. InSAR has been developed into a highly reliable land subsidence monitoring technique that has been utilized by ADWR since 2002. ADWR has identified numerous subsidence features around the State and continues to monitor the extent and rates of these features on an annual basis (ADWR, 2010). In Pima County, ADWR monitors the Green Valley and Tuscon geographical areas using InSAR.

The Planning Team reviewed and chose to use the zones currently being monitored by ADWR to depict the subsidence hazard for the county. Areas defined by ADWR as active subsidence areas were mapped as high hazard zones and all other areas were assigned a low hazard. The high hazard subsidence zones are presented on Maps 5A – 5D.

Vulnerability

Table 4-21: CPRI results for subsidence

Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Unlikely	Critical	< 6 hours	> 1 week	2.35
Oro Valley	Possible	Critical	> 24 hours	> 1 week	2.35
Pascua Yaqui Tribe	Unlikely	Negligible	> 24 hours	< 6 hours	1.00
Sahuarita	Possible	Limited	< 6 hours	< 24 hours	2.30
Tucson	Possible	Critical	< 6 hours	> 1 week	2.80
Unincorporated Pima County	Possible	Limited	< 6 hours	< 24 hours	2.30
				County-wide average CPRI =	**2.18**

Loss Estimations

The estimation of potential exposure to high hazard subsidence areas was accomplished by intersecting the human and facility assets with the subsidence high hazard limits depicted on Maps 5A – 5D. No losses are estimated for facilities located within the high hazard subsidence areas due to lack of appropriate loss-to-exposure data. Table 5-32 summarizes the critical facility, population, and residential housing unit exposure to high subsidence hazards.

In summary, $1.12 billion in county-wide critical facilities are exposed to a high hazard subsidence. An additional $7.94 billion in County-wide Census 2010 residential housing units are estimated to be exposed to a high subsidence hazard. Regarding human vulnerability, a total population of 107,152 people, or 11.04% of the total county-wide population, is potentially exposed to a high hazard levee failure event. It is unlikely that death and injury would result from subsidence, however, secondary impacts related to fissures and flooding may pose additional risk.

Development Trend Analysis

As ADWR continues its mapping and tracking programs, more data will become available for use in regulating future development. Public awareness of the hazard is a key element to any effective mitigation measure, as well as the need to slow the depletion of groundwater sources. New regional drainage features and structures should always refer to the maps in this plan to determine the need for special design considerations that address subsidence.

Table 4-22: Pima County exposure estimates due to subsidence

SUBSIDENCE HAZARD EXPOSURE / LOSS	Marana	Oro Valley	Pascua Yaqui Tribe	Sahuarita	South Tucson	Tucson	Unincorporated Pima County	Total
Total Critical Facilities	**272**	**68**	**16**	**76**	**19**	**1,625**	**1,302**	**3,378**
Facilities Exposed to High Hazard	0	0	0	6	0	290	66	362
Percentage of Total Facilities	0.00%	0.00%	0.00%	7.89%	0.00%	17.85%	5.07%	10.72%
Estimated Replacement Cost (x $1,000)	$0	$0	$0	$5,770	$0	$1,053,052	$64,252	$1,123,074
Estimated Structure Loss (x $,000)	$0	$0	$0	$0	$0	$0	$0	$0
Total Population	**34,622**	**40,557**	**3,675**	**25,142**	**5,593**	**520,368**	**340,692**	**970,648**
Population Exposed to High Hazard	0	0	0	2,824	0	96,796	7,532	107,152
Percent Exposed	0.00%	0.00%	0.00%	11.23%	0.00%	18.60%	2.21%	11.04%
Total Residential Building Count	**14,573**	**20,053**	**892**	**10,549**	**2,112**	**230,157**	**159,016**	**437,352**
Estimated Replacement Cost (x $1,000)	**$3,629,307**	**$6,831,456**	**$187,175**	**$2,229,431**	**$452,144**	**$40,805,270**	**$42,706,058**	**$96,840,841**
Structures Exposed to High Hazard	0	0	0	1,768	0	39,520	2,688	43,976
Percentage of Total Facilities	0.00%	0.00%	0.00%	16.76%	0.00%	17.17%	1.69%	10.06%
Estimated Replacement Cost (x $1,000)	$0	$0	$0	$373,700	$0	$6,996,158	$574,644	$7,944,502
Estimated Structure Loss (x $,000)	$0	$0	$0	$0	$0	$0	$0	$0

Sources

AMEC Earth & Environmental, Inc., 2006, Earth Fissure Risk Zone Investigation Report, Powerline and Vineyard Flood Retarding Structures, Pinal County, AZ, prepared for FCDMC under Contract FCD 2004C503, Work Assignments 1&2.

AZ Dept of Water Resources, 2010, land subsidence http://www.azwater.gov/DWR/Content/Find_by_Program/Hydrology/land-subsidence-in-arizona.htm

Arizona Division of Emergency Management, 2009, State of Arizona Multi-Hazard Mitigation Plan

AZ Land Subsidence Group, 2007. Land subsidence and earth fissures in AZ Research and informational needs for effective risk management, white paper, Tempe, AZ, http://www.azgs.az.gov/Earth%20Fissures/CR-07-C.pdf

Carpenter, M.C., 1999, Land subsidence in the United States, South-Central Arizona: Earth fissures and subsidence complicate development of desert water resources, [Galloway, D., Jones, D.R., and Ingebritson, S.E., editors], USGS Circular 1182.

Carruth, R.L. Pool, D.R., Anderson, C.E., 2008, *Land Subsidence and Aquifer Compaction in the Tucson Active Management Area, South-Central Arizona—1987–2005*, http://cals.arizona.edu/AZWATER/awr/1ea38059-c0a8-0164-00b5-7927a2dcf093-usgs-supplementjanfeb08-final.pdf#xml=http://ag3.calsnet.arizona.edu/cgi-bin/texis/webinator/search/xml.txt?query=subsidence&pr=azwater&prox=page&rorder=500&rprox=500&rdfreq=500&rwfreq=500&rlead=500&sufs=0&order=r&cq=&id=4e9ad6802

FEMA, 2001, Understanding Your Risks; Identifying Hazards and Estimating Losses, FEMA Document No. 386-2.

Gelt, J., 1992, *Land Subsidence, Earth Fissures Change Arizona's Landscape*, Arroyo Vol 6, No. 2, published by the University of Arizona, Water Resources Research Center, http://cals.arizona.edu/AZWATER/arroyo/062land.html

Maps

Maps 5A and 5B – County-Wide and Tucson Metro Area Subsidence Hazard Map(s)

Maps 5C and 5D – Jurisdiction Specific Subsidence Hazard Maps for Sahuarita and Tucson.

4.4.10 Wildfire

Description

A wildfire is an uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures. They often begin unnoticed, spread quickly, and are usually signaled by dense smoke. Wildfires can be human-caused through acts such as arson, campfires, or the improper burning of debris, or can be caused by natural events such as lightning. Wildfires can be categorized into four types:

- ***Wildland fires*** occur mainly in areas under federal control, such as national forests and parks, and are fueled primarily by natural vegetation. Generally, development in these areas is nonexistent, except for roads, railroads, power lines, and similar features.
- ***Interface or intermix fires*** occur in areas where both vegetation and structures provide fuel. These are also referred to as urban-wildland interface fires.
- ***Firestorms*** occur during extreme weather (e.g., high temperatures, low humidity, and high winds) with such intensity that fire suppression is virtually impossible. These events typically burn until the conditions change or the fuel is exhausted.
- ***Prescribed fires and prescribed natural fires*** are intentionally set or natural fires that are allowed to burn for beneficial purposes.

The following three factors contribute significantly to wildfire behavior and, as detailed more fully later, they can be used to identify wildfire hazard areas:

- ***Topography***: As slope increases, the rate of wildfire spread increases. South facing slopes are also subject to greater solar radiation, making them drier and thereby intensifying wildfire behavior. However, ridgetops may mark the end of wildfire spread, since fire spreads more slowly or may even be unable to spread downhill.
- ***Fuel:*** Wildfires spread based on the type and quantity of available flammable material, referred to as the fuel load. The basic characteristics of fuel include size and shape, arrangement and moisture content. Each fuel is assigned a burn index (the estimated amount of potential energy released during a fire), an estimate of the effort required to contain a wildfire, and an expected flame length.
- ***Weather:*** The most variable factor affecting wildfire behavior is weather. Important weather variables are temperature, humidity, wind, and lightning. Weather events ranging in scale from localized thunderstorms to large fronts can have major effects on wildfire occurrence and behavior. Extreme weather, such as high temperatures and low humidity, can lead to extreme wildfire activity. By contrast, cooling and higher humidity often signals reduced wildfire occurrence and easier containment. Wind has probably the largest impact on a wildfire's behavior, and is also the most unpredictable. Winds supply the fire with additional oxygen, further dry potential fuel, and push fire across the land at a quicker pace.

The frequency and severity of wildfires is also impacted by other hazards, such as lightning, drought, and infestations (e.g., Pine Bark Beetle). In Arizona, these hazards combine with the three other wildfire contributors noted above (topography, fuel, weather) to present an on-going and significant hazard across much of Arizona.

If not promptly controlled, wildfires may grow into an emergency or disaster. Even small fires can threaten lives, resources, and destroy improved properties. It is also important to note that in addition to affecting people, wildfires may severely affect livestock and pets. Such events may require the emergency watering/feeding, shelter, evacuation, and increased event-caused deaths and burying of animals.

The indirect effects of wildfires can also be catastrophic. In addition to stripping the land of vegetation and destroying forest resources, large, intense fires can harm the soil, waterways and the land itself. Soil exposed to intense heat may lose its capability to absorb moisture and support life. Exposed soils erode quickly and enhance siltation of rivers and streams thereby enhancing flood potential, harming aquatic life and degrading water quality. Lands stripped of vegetation are also subject to increased landslide hazards.

History

Wildfires have a prominent history in Pima County. According to Tables 5-2 and 5-3, Pima County has been included in 17 state and/or federal wildfire disaster declarations. For the period of 1980 to 2008, data compiled by the Arizona State Forestry Division for the 2010 State Plan update indicates that at least 164 wildfires greater than 100 acres in size have occurred in all of Pima County. There have been three wildfires that burned more than 10,000 acres in the last ten years, and are described below in chronological order:

- In May of 2002, the Bullock Fire started in Bullock Canyon in the Catalina Mountains on the Coronado National Forest. The fire started on May 21st and continued through June 10th. It was suspected to be human induced. The fire burned 30,563 acres along with 2 cabins and several outbuildings. The residents of Summerhaven were evacuated on May 25th and Catalina Highway closed on May 22nd. The fire also threatened Mt. Bigelow which had several telecommunication towers and 2 telescopes, however, fire fighters were able to contain the fire a half of a mile away. The entire fire fight costs were estimated to be $14.3 million (NWCG, 2010).
- In June of 2003, the Aspen Fire was started by human causes on June 17, 2003 and burned for about a month on Mount Lemmon, which is part of the Santa Catalina Mountains located in the Coronado National Forest north of Tucson. The fire burned 84,750 acres of land, and destroyed 333 homes and businesses in the community of Summerhaven. Electric lines, phone lines, water facilities, streets and sewers were also damaged. Total property damages were estimated to exceed $66 million. Fire fight costs were estimated to exceed $17 million, and the Forest Service spent an estimated $2.7 million dollars to prevent soil loss. The losses in terms of timber for future lumber are estimated at $33 million. In 2002, the year before the fire started, Congress had been requested to allocate about $2,000,000 to cover the implementation of fire prevention measures in the Coronado National Forest. However, that allocation was reduced to about $150,000 in the Congressional budget process. A presidential disaster declaration (FEMA-1477-DR) was made on July 14, 2003. (ADEM, 2008; NWCG, 2010 and Wikipedia, 2008 at: http://en.wikipedia.org/wiki/Aspen_Fire).
- In June of 2009, the Elk Horn Fire was started by human causes and an area 26 miles southwest of Three Points, Arizona. The fire started June 11, 2009 and was contained on June 22, 2009. The fire burned a total 23,440 acres with $1M plus in fire suppression costs and 5 reported injuries related to fire fight efforts.

There have been 26 wildfires in excess of 100 acres for the period of 2002 to 2009. Map 6A and 6B provides a graphical depiction of the 100 acre plus wildfires for that period.

The Planning Team recognized that the declared disaster and historic hazard data collected and summarized in Section 5.1 does not adequately reflect the true cost of a wildfire, particularly, the cost of suppression efforts. For example, a realistic damage estimates for the two residences and five outbuildings destroyed by the Bullock Fire would likely be less than $250,000. However, the suppression costs for the Bullock Fire exceeded $14.3 million. Furthermore, the County, State, Forest Service, and other agencies spend millions of dollars every year in wildfire mitigation in fuel treatment projects.

Probability and Magnitude

The probability and magnitude of wildfire incidents for Pima County are influenced by numerous factors including vegetation densities, previous burn history, hydrologic conditions, climatic conditions such as temperature, humidity, and wind, ignition source (human or natural), topographic aspect and slope, and remoteness of area. Wildfire risk for Pima County was mapped based on the data developed for the Pima County Community Wildfire Protection Plan (LSDI, 2011). Pima County and participating jurisdictions and organizations developed the Pima County Community Wildfire Protection Plan (PCCWPP) to help local governments, fire departments and districts, and residents identify at-risk public and private lands to better protect those lands from a severe wildfire threat.

The PCCWPP identified two models of wildland fuel hazards to represent a typical year of rainfall and an extraordinarily heavy rainfall year to present a range of wildland fuel hazards across the County. Each model divided the fuel hazard into three categories; high, medium and low and accounted for previous burn areas and the major buffelgrass concerns. The extraordinary fuels hazard map from the PCCWPP is shown in Figure 5-12. The high, medium and low fuel hazard risks were adopted by the Planning Team to represent the high, medium, and low wildfire risk in this Plan.

Maps 6A and 6B show the wildfire hazard areas on a county-wide basis and the Tucson Metro area, respectively. Maps 6C through 6H show the wildfire hazard areas for each of the jurisdictions.

Vulnerability

Table 4-23: CPRI results for wildfire

Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Possible	Critical	< 6 hours	< 1 week	2.70
Oro Valley	Possible	Limited	< 6 hours	< 1 week	2.40
Pascua Yaqui Tribe	Likely	Limited	< 6 hours	< 24 hours	2.75
Sahuarita	Possible	Limited	< 6 hours	< 1 week	2.40
Tucson	Unlikely	Negligible	< 6 hours	< 1 week	1.65
Unincorporated Pima County	Highly Likely	Critical	< 6 hours	< 1 week	3.60
				County-wide average CPRI =	**2.58**

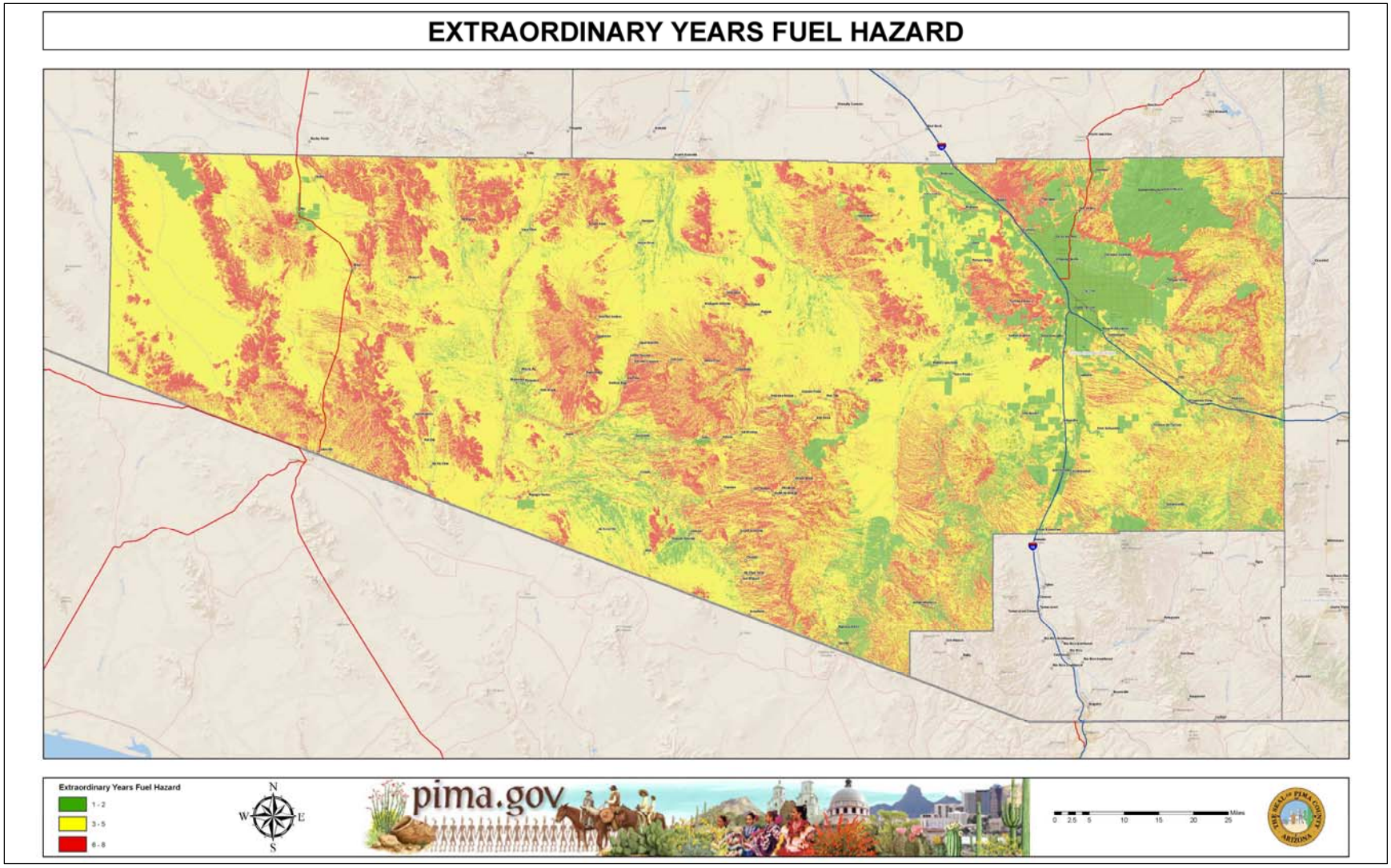
Loss Estimations

The estimation of potential exposure to high and medium wildfire hazards was accomplished by intersecting the human and facility assets with the wildfire hazard limits depicted on Maps 6A – 6H. Loss to exposure ratios of 0.20 (20%) and 0.05 (5%) were assumed to estimate losses for all facilities located within the high and medium wildfire hazard areas, respectively. Table 5-35 summarizes the critical facility, population, and residential housing unit exposure and loss estimates for high and medium wildfire hazards.

In summary, $0.41 and $1.27 billion in county-wide critical facilities are exposed to a high hazard subsidence, with estimated losses of $82.8 and $63.3 million, respectively. An additional $2.89 and $10.87 billion in county-wide Census 2010 residential housing units are estimated to be exposed to a high and medium wildfire hazard. Census 2010 residential housing unit loss estimates for the high and medium wildfire events are $578 and $543 million. Regarding human vulnerability, a total population of 25,448 people, or 2.62% of the total county-wide population, is potentially exposed to a high hazard wildfire event. Similarly, 112,750 people, or 11.62% of the total county-wide population is exposed to a medium wildfire hazard. Typically, deaths and injuries not related to firefighting activities are rare. However, it is feasible to assume that at least one death and/or injury may be plausible. There is also a high probability of population displacement during a wildfire event, and especially in the urban wildland interface areas.

It is noted that these exposure and loss dollar amounts do not include the cost of wildfire suppression which can be substantial. For example, a Type 1 wildfire fighter crew costs about $1 million per day to operate.

It is also noted that the loss and exposure numbers presented above represent a comprehensive evaluation of the county as a whole. It is unlikely that a wildfire would occur that would impact all of the high and medium wildfire hazard areas at the same time. Accordingly, actual event based losses and exposure are likely to be only a fraction of those summarized above.



Source: Pima County CWPP (LSDI, 2011)

Map 4-7: PCCWPP extraordinary rainfall year fuel hazards

Table 4-24: Pima County exposure and loss estimates due to wildfire

WILDFIRE HAZARD EXPOSURE / LOSS	Marana	Oro Valley	Pascua Yaqui Tribe	Sahuarita	South Tucson	Tucson	Unincorporated Pima County	Total
Total Critical Facilities	**272**	**132**	**16**	**76**	**19**	**1,625**	**1,302**	**3,442**
Facilities Exposed to High Hazard	34	12	4	0	0	42	129	221
Percentage of Total Facilities	12.50%	9.09%	25.00%	0.00%	0.00%	2.58%	9.91%	6.42%
Estimated Replacement Cost (x $1,000)	$5,729	$7,180	$222,516	$0	$0	$19,696	$165,589	$420,709
Estimated Structure Loss (x $,000)	$1,146	$1,436	$44,503	$0	$0	$3,939	$33,118	$84,142
Facilities Exposed to Medium Hazard	38	27	0	32	0	80	318	495
Percentage of Total Facilities	13.97%	20.45%	0.00%	42.11%	0.00%	4.92%	24.42%	14.38%
Estimated Replacement Cost (x $1,000)	$92,431	$47,007	$0	$157,606	$0	$286,394	$699,599	$1,283,037
Estimated Structure Loss (x $1,000)	$4,622	$2,350	$0	$7,880	$0	$14,320	$34,980	$64,152
Total Population	**34,622**	**40,557**	**3,675**	**25,142**	**5,593**	**520,368**	**340,692**	**970,648**
Population Exposed to High Hazard	4,302	3,464	7	274	0	3,875	13,525	25,448
Percent Exposed	12.43%	8.54%	0.20%	1.09%	0.00%	0.74%	3.97%	2.62%
Population Exposed to Medium Hazard	9,276	5,538	222	18,063	0	24,294	55,356	112,750
Percent Exposed	26.79%	13.65%	6.03%	71.84%	0.00%	4.67%	16.25%	11.62%
Total Residential Building Count	**14,573**	**20,053**	**892**	**10,549**	**2,112**	**230,157**	**159,016**	**437,352**
Estimated Replacement Cost (x $1,000)	**$3,629,307**	**$6,831,456**	**$187,175**	**$2,229,431**	**$452,144**	**$40,805,270**	**$42,706,058**	**$96,840,841**
Structures Exposed to High Hazard	2,026	1,647	2	158	0	1,391	5,943	11,167
Percentage of Total Facilities	13.90%	8.21%	0.22%	1.50%	0.00%	0.60%	3.74%	2.55%
Estimated Replacement Cost (x $1,000)	$504,660	$561,000	$434	$33,494	$0	$246,920	$1,543,609	$2,890,117
Estimated Structure Loss (x $,000)	$100,932	$112,200	$87	$6,699	$0	$49,384	$308,722	$578,024
Structures Exposed to Medium Hazard	3,579	2,635	53	7,072	0	8,815	23,430	45,584
Percentage of Total Facilities	24.56%	13.14%	5.94%	67.04%	0.00%	3.83%	14.73%	10.42%
Estimated Replacement Cost (x $1,000)	$890,877	$897,515	$10,657	$1,494,751	$0	$1,572,964	$6,000,795	$10,867,559
Estimated Structure Loss (x $1,000)	$44,544	$44,876	$533	$74,738	$0	$78,648	$300,040	$543,379

Development Trend Analysis

By its very definition, the Wildland Urban Interface (WUI) represents the fringe of urban development as it intersects with the natural environment. As previously discussed, wildfire risks are significant for a sizeable portion of the county. Any future development will only increase the WUI areas and expand the potential exposure of structures to wildfire hazards.

Sources

Arizona Division of Emergency Management, 2010, State of Arizona Multi-Hazard Mitigation Plan

Fisher, M., 2004, Arizona Wildland Urban Interface Assessment, prepared for the Arizona Interagency Coordination Group. http://www.azsf.az.gov/UserFiles/PDF/Arizona%20Wildland%20Urban%20Interface%20Assessment%2005MAR04.pdf

Logan Simpson Design, Inc., 2011, *Pima County Community Wildfire Protection Plan (DRAFT)*

National Wildfire Coordination Group, 2010, Historical ICS 209 reports at: http://fam.nwcg.gov/fam-web/hist_209/report_list_209

White, Seth, 2004, *Bridging the Worlds of Fire Managers and Researchers: Lessons and Opportunities From the Wildland Fire Workshops,* USDA Forest Service, General Technical Report PNW-GTR-599, March 2004

Maps

Maps 6A and 6B – County-Wide and Tucson Metro Wildfire Hazard Map(s)

Maps 6C through 6H – Jurisdiction Specific Wildfire Hazard Maps

4.4.11 Winter Storm

Description

Severe winter storms affect many aspects of life in the county including; transportation, emergency services, utilities, agriculture and the supply of basic subsistence to isolated communities. U.S and state highways have produced numerous fatal multi-car accidents due to heavy winter snowfall and icy road conditions. Heavy snowfalls can also leave motorists stranded in their vehicles with potentially disastrous results like hypothermia and carbon-monoxide poisoning. Significant winter storms can also hinder both ground and air emergency services vehicles from responding to accidents or other emergencies. Remote areas and communities can be easily cut-off from basic resources such as food, water, electricity, and fuel for extended periods during a heavy storm. Extremely heavy snow storms can produce excessive snow loads that can cause structural damage to under-designed buildings. Agricultural livestock can also be vulnerable to exposure and starvation during heavy winter storms.

Freezing Rain is formed as snow falls through a warm zone in the atmosphere completely melting the snow. The melted snow then passes through another zone of cool air "super cooling" the rain below freezing temperature while still in a liquid state. The rain then instantly freezes when it comes in contact with the ground or other solid object. Because freezing rain hits the ground as a rain droplet, it conforms to the shape of the ground, making one thick layer of ice. Sleet is similar to hail in appearance but is formed through atmospheric conditions more like Freezing Rain. The difference is the snowflakes don't completely thaw through the warm zone and then freeze through the cool air zone closer to the ground. Sleet typically bounces as it hits a surface similar to hail. Sleet is also informally used to describe a mixture of rain and snow and is sometimes used to describe the icy coating on trees and powerlines.

Sleet and freezing rain can cause slippery roadway surfaces and poor visibility leading to traffic accidents, and can leave motorists stranded in their vehicles with potentially disastrous results like hypothermia and carbon monoxide poisoning. Heavy sleet or freezing rain can produce excessive ice-loads on powerlines, telecommunication lines and other communication towers, tree limbs, and buildings causing power outages, communication disruptions, and other structural damage to under-designed facilities.

History

For the majority of Pima County, winter snow is unusual and winter storm events are rare. The heaviest winter snows usually occur at the higher elevation areas of the Santa Catalina, Baboquivari, Rincon, Whetstone, and Santa Rita Mountains and foothills. The following are highlights of the more prominent winter storm events impacting Pima County:

- In November 1958, 6.4 inches of snow fell across the Tucson metro area and caused auto accidents, stranded people, dropped power lines, knocked out telephone service, closed highways and paralyzed air travel. Three boy scouts were stranded in snow near Madera Canyon in the Santa Rita Mountains south of Tucson. Their bodies were not found for two weeks. The heavy snow also closed the highway to Mt. Lemmon, marooning about 35 weekend vacationers (NWS Tucson, 2011).
- In December 1971, 6.8 inches of snow blanketed the Tucson metro area after midnight. The heavy snow snarled traffic, closed the airport, downed power lines and damaged or destroyed 3000 trees, some of them 20 years old. Slush on the runway forced the closure of the Tucson International Airport and cancellation of flights between 6 AM and 11 AM. At the time, the airport did not own a snow plow (NWS Tucson, 2011).

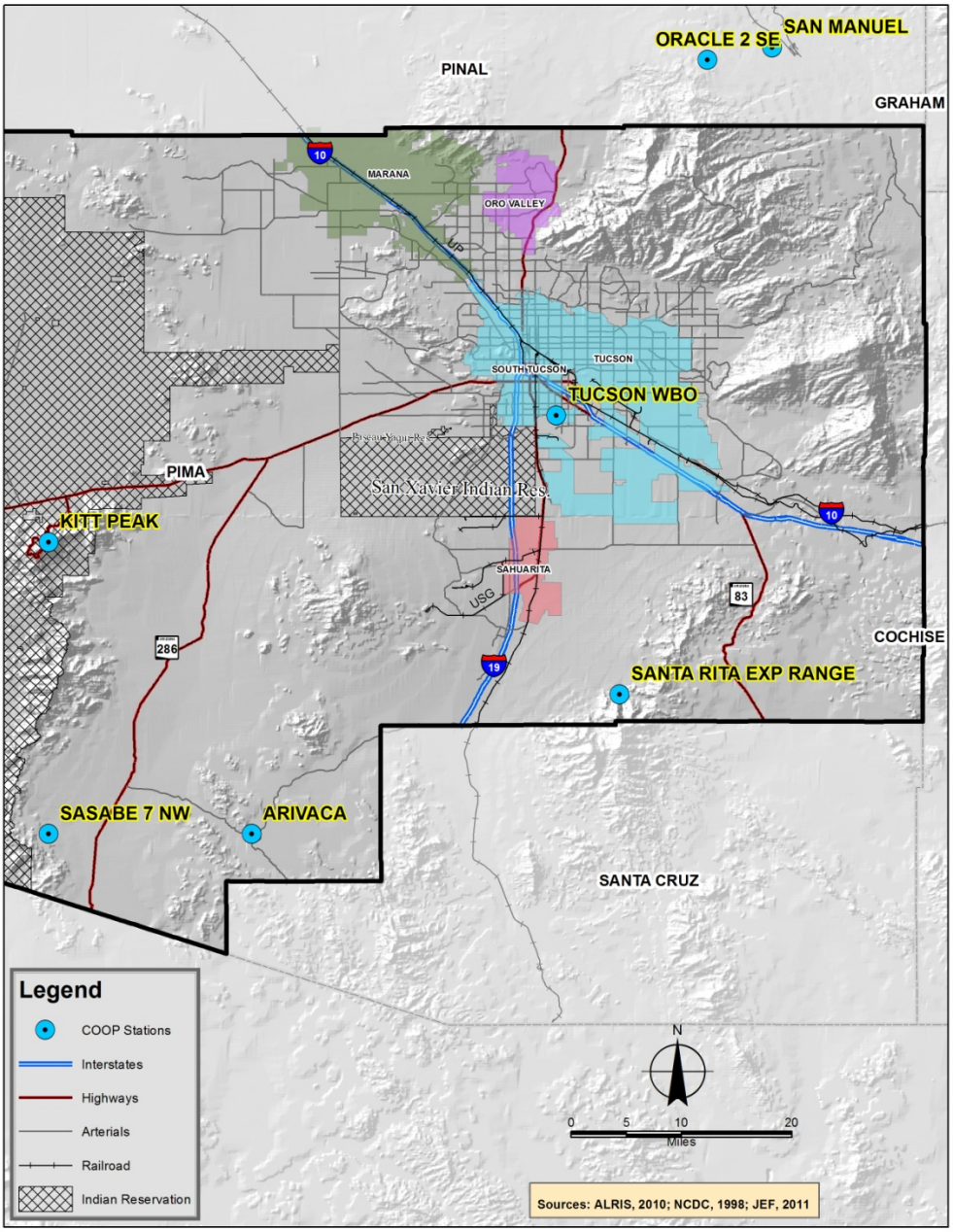
Probability and Magnitude

Snow level measurements are recorded daily across the United States and can be used to estimate the probability and frequency of severe winter storms. In Arizona, there is a 5% annual chance that snow depths between zero and 25 centimeters will be exceeded, a snowfall probability that is among the lowest in the nation (ADEM, 2009).

The NCDC has compiled snow climatology statistics for Arizona and the rest of the conterminous 48 states, using historic data from National Weather Service cooperative observer sites for the period of 1948 to 1996 (NOAA/NCDC, 1998). The NCDC used these data sets to develop 1-, 2-, and 3-day, 10-, 25-, 50-, and 100-year recurrence interval snowfall depth estimates for each of the statistically eligible[15] stations. There were six stations for which statistics were calculated in or near Pima County and the results are summarized in Table 5-37. The station locations are shown

[15] Those stations with sufficient continuous data.

on Figure 5-3. It is notable that none of the stations are located on Mount Lemmon, which would be expected to have the greatest potential for snowfall depths in the county.



Map 4-8: Weather stations with snowfall within or near Pima Co

Table 4-25: Probability estimates of snowfall depth within or near Pima County

Snowfall Duration	Snowfall Amount, in inches					Non-Zero Data	Non-Missing Data
	Return Period				Observed Maximum		
	10-year	25-year	50-year	100-year			
Station: ARIVACA; Elev = 3,620 FT; Period of Record: 1956-1996							
1-day	3.8	5.4	6.8	8.3	6.5	31	41
2-day	4.3	6	7.4	8.9	6.5	31	41
3-day	4.6	6.4	7.9	9.5	6.5	31	41
August-July	7.8	11.2	14.2	17.5	13.3	30	38
Station: KITT PEAK; Elev = 6,790 FT; Period of Record: 1960-1996							
1-day	13.3	16.9	19.5	22	19	35	36
2-day	16.7	21.4	24.9	28.3	25	35	36
3-day	18.5	24.9	30.1	35.7	31.5	35	36
August-July	46.9	61	71.9	83.3	77.5	22	22
Station: SANTA RITA EXP RANGE; Elev = 4,300 FT; Period of Record: 1950-1996							
1-day	4.7	7.8	11	15.1	10	24	46
2-day	4.9	8.2	11.6	16	10	24	46
3-day	5.1	8.7	12.6	17.7	12	24	46
August-July	N/A	N/A	N/A	N/A	24	17	21
Station: SASABE 7 NW; Elev = 3,824 FT; Period of Record: 1950-1996							
1-day	4.6	7.5	10.4	14.1	12	29	46
2-day	4.7	7.6	10.5	14.1	12	29	46
3-day	4.7	7.6	10.5	14.2	12	29	46
August-July	N/A	N/A	N/A	N/A	9	17	27
Station: TUCSON WBO; Elev = 2,584 FT; Period of Record: 1948-1996							
1-day	2.4	4.4	6.7	9.8	6.8	23	49
2-day	2.7	4.9	7.4	10.8	6.8	23	49
3-day	2.7	4.9	7.4	10.8	6.8	23	49
August-July	3.5	6	8.7	12.3	6.8	23	47
Station: ORACLE 2 SE; Elev = 4,510 FT; Period of Record: 1950-1996							
1-day	9.5	12.8	15.3	18	15	38	47
2-day	11.1	15.4	18.9	22.7	18	38	47
3-day	11.6	16.4	20.6	25.2	19	38	47
August-July	22.9	32.3	40.4	49.7	41	30	31

The NCDC also maintains a snow climatology data set that contains maximum 1-day, 2-day, and 3-day duration snow depths at various weather stations across the nation (except Hawaii). The data reflects the maximum depth of snowfall recorded as of 2006. Maps 7A and 7B represent a county-wide and Tucson Metro graphical depiction of zones of historically maximum 1-day duration snowfall depths. Maps 8A and 8B are similar, only depicting zones for the historically maximum 3-day duration snowfall depths. Bordering gage stations in California, Nevada, Utah, Colorado, and New Mexico were also used to ensure that no boundary effects were created.

Vulnerability

Table 4-26: CPRI results for winter storm

Participating Jurisdiction	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI Score
Marana	Possible	Critical	12 to 24 hours	< 1 week	2.40
Oro Valley	Likely	Limited	6 to 12 hours	< 1 week	2.70
Pascua Yaqui Tribe	Unlikely	Negligible	> 24 hours	< 6 hours	1.00
Sahuarita	Unlikely	Negligible	> 24 hours	< 6 hours	1.00
Tucson	Unlikely	Negligible	12-24 hours	< 1 week	1.65
Unincorporated Pima County	Highly Likely	Critical	< 6 hours	< 1 week	3.60
				County-wide average CPRI =	**2.06**

Loss Estimations

There are no standardized methods for estimating losses associated with winter storm events and none are made for this Plan. From a historical perspective, both human and infrastructure losses could be expected with any major winter storm event, and especially regarding traffic accidents and human exposure. This is especially true in Pima County since significant snowfall events are rare and the general population is not likely to be prepared for such an event.

Development Trend Analysis

Winter Storm effects as they relate to snow and ice, will not pose much of a risk to most future development within Pima County. Development of areas above 6,000 feet is at greatest risk, but those areas are well outside of the urban core of the Tucson metro area. Enforcement and/or implementation of modern building codes to regulate new developments in conjunction with public education on how to respond to hazardous winter conditions is probably the best way to mitigate against such losses.

Sources

Arizona Division of Emergency Management, 2010, State of Arizona Multi-Hazard Mitigation Plan

National Weather Service, Flagstaff Forecast Office, 2011,
http://www.wrh.noaa.gov/fgz/safety/criteria.php?wfo=fgz

NOAA/National Climatic Data Center, 1998, *United States Snow Climatology*, TD-9641

U.S. Dept of Commerce, National Climatic Data Center, 2010, Storm Events Database,
http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

U.S. Dept of Commerce, National Climatic Data Center, 2010, U.S. Snow Climatology Project,
http://www.ncdc.noaa.gov/ussc/USSCAppController?action=map

Maps

Maps 7A and 7B – County-Wide and Tucson Metro Maximum 1-Day Snow Depths

Maps 8A and 8B – County-Wide and Tucson Metro Maximum 3-Day Snow Depths

4.5 Risk Assessment Summary

The jurisdictional variability of risk associated with each hazard assessed in Section 5.3 is demonstrated by the various CPRI and loss estimation results. Accordingly, each jurisdiction has varying levels of need regarding the hazards to be mitigated, and may not consider all of the hazards as posing a great risk to their individual communities. Table 5-40 summarizes the hazards selected for mitigation by each jurisdiction and will be the basis for each jurisdictions mitigation strategy.

Table 4-27: Hazards to be mitigated by each jurisdiction

Jurisdiction	Disease	Drought	Earthquake	Extreme Temperature	Flood	HAZMAT	Levee Failure	Severe Wind	Subsidence	Wildfire	Winter Storm
Unincorporated Pima County	x				x		x				
Marana					x	x				x	
Oro Valley	x	x		x	x	x				x	x
Pascua Yaqui Tribe	x	x	x		x			x		x	
Sahuarita	x			x	x	x				x	
South Tucson	No Data Provided by Jurisdiction										
Tucson		x	x		x			x	x		

SECTION 5: MITIGATION STRATEGY

5.1 Section Changes

The mitigation strategy provides the "what, when, and how" of actions that will reduce or possibly remove the community's exposure to hazard risks. The primary components of the mitigation strategy are:

Goals and Objectives

Capability Assessment

Mitigation Actions/Projects and Implementation Strategy

The entire 2007 Plan mitigation strategy was reviewed and updated by the Planning Team, including a major re-organization of the mitigation strategy elements into this multi-jurisdictional plan format. Specifics of the changes and updates are discussed in the subsections below.

5.2 Hazard Mitigation Goals and Objectives

An assessment of those goals and objectives by the Planning Team was made with consideration of the following[16]:

- Do the goals and objectives identified in the 2007 Plan reflect the updated risk assessment?
- Did the goals and objectives identified in the 2007 Plan lead to mitigation projects and/or changes to policy that helped the jurisdiction(s) to reduce vulnerability?
- Do the goals and objectives identified in the 2007 Plan support any changes in mitigation priorities?
- Are the goals and objectives identified in the 2007 Plan reflective of current State goals?

- **GOAL:** Reduce or eliminate the risk to people and property from natural or human caused hazards.
  - **Objective 1:** Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
  - **Objective 2:** Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
  - **Objective 3:** Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
  - **Objective 4:** Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

5.3 Capability Assessment

An important component of the Mitigation Strategy is a review of each participating jurisdiction's resources in order to identify, evaluate, and enhance the capacity of local resources to mitigate the effects of hazards. The capability assessment is comprised of several components:

- Legal and Regulatory Review – a review of the legal and regulatory capabilities, including ordinances, codes, plans, manuals, guidelines, and technical reports that address hazard mitigation activities.
- Technical Staff and Personnel – this assessment evaluated and describes the administrative and technical capacity of the jurisdiction's staff and personnel resources.
- Fiscal Capability – this element summarizes each jurisdiction's fiscal capability to provide the financial resources to implement the mitigation strategy.

The Planning Team reviewed the information provided in Section 6.1 of the 2007 Plan, and specifically Tables 6-1 through 6-24. The Planning Team chose to generally keep the format of the tables summarizing the administrative, technical, and fiscal capabilities. A new table was developed to summarize the legal and regulatory capabilities by

[16] FEMA, 2008, *Local Multi-Hazard Mitigation Planning Guidance*

better summarizing and identifying the codes, ordinances, plans, and studies/reports used by a jurisdiction, as well as identify the appropriate agency/department with responsibility for maintaining and updating those documents.

Jurisdictional Capabilities

Tables 6-1-1 through 6-1-6 summarize the legal and regulatory mitigation capability for each participating jurisdiction. Information provided includes a brief listing of current codes, mitigation relevant ordinances, plans, and studies/reports. Tables 6-2-1 through 6-2-6 summarize the staff and personnel resources employed by each jurisdiction that serve as a resource for hazard mitigation. Tables 6-3-1 through 6-3-6 summarize the fiscal capability and budgetary tools available to each participating jurisdiction. Each of these three tables are listed below by jurisdiction.

Table 5-1-1: Pima County Legal and Regulatory Capabilities

Regulatory Tools for Hazard Mitigation	Description	Responsible Department/Agency
CODES	• 2006 International Building, Property Maintenance, Fuel Gas, Plumbing, Mechanical, Energy Conservation, Residential and Wildland-Urban Interface Code • 2005 National Electrical Code	• Development Services • Facilities Management • Department of Environmental Quality • Natural Resources, Parks & Recreation

ORDINANCES	• Pima County Code of Ordinances
	  • Title 7, Environmental Quality
	  • Title 8, Health & Safety
	  • Title 9, Public Peace, Morals & Welfare
	  • Title 15, Buildings & Construction
	  • Title 16, Floodplain and Erosion Hazard Management Ordinance (2010)
	  • Title 17, Air Quality Control
	  • Title 18, Zoning
		• Facilities Management
		• Wastewater Management
		• Department of Environmental Quality
		• Regional Flood Control District
		• Health Department

PLANS, MANUALS, and/or GUIDELINES	• Pima Co Hazard Mitigation Plan (2007)
	• Stormwater Detention/Retention Manual (1984)
	• Drainage and Channel Design Standards for Local Drainage Manual (1984)
	• Technical Policies (Interpretation of the Title 16 and Other Regulatory Documents – see below):
	  • 001 Completion of elevation Certification-Qualification (2006)
	  • 002 Erosion Hazard Setback Reductions to <25 feet (2006)
	  • 003 Minimum Construction Standards for MHs (2010)
	  • 004 Design of Flood Venting (2006)
	  • 005 Minimum Requirements for Walls and Fences (2007)
	  • 006 Erosion Protection for Fill Pads (2007)
	  • 007 Applicability of the Detention/Retention Requirements
		• Development Services
		• Regional Flood Control District

Table 5-1-1: Pima County Legal and Regulatory Capabilities		
Regulatory Tools for Hazard Mitigation	**Description**	**Responsible Department/Agency**
	• 008 Minimum Standards for Security Barriers (2006) • 009 Design of Landscaping in Basins and Channels (2006) • 010 Rainfall Input for Hydrologic Modeling (2007) • 011 Permitting for Accessory Structures (2009) • 012 Permitting of Existing Improvements (pending) • 013 Regulation of Shaded Zone X Classifications (2009) • 014 Erosion Protection of Stem Wall foundations (2009) • 015 Hydrologic Model Selection for Peak Discharge Determination • 016 Hydraulic Model Selection for Floodplain Delineation (2007) • 017 Acceptable Methods for Channel Design and Scour Calculations (pending) • 018 Acceptable Model Parameterization for Determining Peak Discharges (2011) • 019 Standards for Floodplain Hydraulic Modeling (pending) • 020 Anchoring Requirements for Sheds and Tanks (pending) • 021 Use of Flood Resistant Materials Below the RFE (2008) • 022 Allowable Uses of Enclosed Areas with Flood Openings (2009) • 023 Allowable Uses of Enclosed Areas with Flood Openings (2009) • 024 Avoiding Riparian Habitat-Requirement pending) • 025 Sand and Gravel Permitting Guidelines (pending) • 026 Interim Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines (2010) • 027 Protective Measures for Private Vehicular Access (pending) • 028 Pre-Ordinance Agricultural Berms, Channels and Stock Ponds (pending) • 029 Electrical Facilities That Are Considered “Critical Facilities” • Sonoran Conservation Plan • Pima County Sustainability Program • Pima County Comprehensive Plan	

Table 5-1-1: Pima County Legal and Regulatory Capabilities

Regulatory Tools for Hazard Mitigation	Description	Responsible Department/Agency
STUDIES	• 1999 Flood Insurance Study, Pima County Unincorporated Areas • FEMA DFIRM Maps (FEMA, Effective date of June 2011) • Special Floodplain Studies (see below) • 1983 Special Study 02 – Critical Watershed Management Plan Ruthrauff Road Area • 1986 Special Study 03 – Flecha Caida Flood Improvement Study • 1986 Special Study 04 – Tucson Mountain Basin Study • 1986 Special Study 05 - Highlands Wash Basin Management Plan Report • 1987 Special Study 06 - Riverside Terrace Basin Management Plan • 1988 Special Study 07 - Ventana Canyon Estates, Erosion Setback Limits • 1988 Special Study 08 - Millstone Manor No. 6 • 1988 Special Study 09 - Sutherland Wash, H&H Report • 2009 Special Study 10 - Lee Moore Wash Basin Management Study • 1989 Special Study 11 - Green Valley Drainageway No.9 • 1989 Special Study 12 - Valley View Wash, Flecha Caida Flood Phase 2 • 1990 Special Study 13 - Holladay Street & Forrest Avenue Watershed Study • 1990 Special Study 14 - Southwest Basin Management Study • 1990 Special Study 15 - Black Wash Drainage Analysis • 2004 Special Study 16 - [Upper] Canada Del Oro Wash Letter of Map Revision Study • 1992 Special Study 17 - Fortyniner's Interior Drainage Improvements • 2010 Special Study 18 - Soldier Wash and its Tributary • 1992 Special Study 19 - Tortolita Mountains Geomorphic Assessment • 1993 Special Study 20 - Valencia Wash Basin Management Study • 1992 Special Study 21 - Upper Carmack, South Branch, Sub-Basin Management Study	• Regional Flood Control District

Table 5-1-1: Pima County Legal and Regulatory Capabilities

Regulatory Tools for Hazard Mitigation	Description	Responsible Department/Agency
	• 1992 Special Study 22 - 27 Mile Wash Flood Plain Delineation Study • 1993 Special Study 23 - TanqueVerde Creek Management Study • 1993 Special Study 24 - Tortolita Area Basin Management Plan • 1993 Special Study 25 - Mt. Lemmon Culvert Study • 1994 Special Study 26 - Southwest Basin Management Study Ph. II Part A • 1995 Special Study 27 - New Tucson, Units 21, 22, 23, 24 & 27, Erosion-Hazard Setback Analysis for Unit 23 • 1994 Special Study 28 - Hydrology/Hydraulics Report for Demetrie Wash • 1994 Special Study 30 - Hydrologic/Hydraulic Report for Palo Verde Ranch • 1996 Special Study 31 - Brawley Wash Floodplain Study • 1996 Special Study 32 - New Tucson Units 26, 28, 29 & 30 • 1995 Special Study 34 - 49ers Country Club Lots 315 to 324 • 1999 Special Study 35 - Earp Wash • 2009 Special Study 36 - Camino Real Wash Letter of Map Revision • 1999 Special Study 37 - Camino de Oeste Wash • 2000 Special Study 38 - Sahuarita Basin Management Study • 2000 Special Study 39 - HEC-1 and FLO 2-D Models for Finger Rock Wash • Special Study 40 - Mission Wash Study for FEMA • 1999 Special Study 42 - Brawley Wash Primary Flood Corridor Study • 1995 Special Study 43 - Idle Hour Wash Letter of Map Revision • 1983 Special Study 44 - Central Arizona Project (CAP) Tucson Aqueduct • 2003 Special Study 45 - Summerhaven Hydrologic and Hydraulic Analysis • 2007 Special Study 46 - Sheet Flood Mapping for Unincorporated Pima Co • 2003 Special Study 47 - Silverbell Trails Estates	

Table 5-1-1: Pima County Legal and Regulatory Capabilities

Regulatory Tools for Hazard Mitigation	Description	Responsible Department/Agency
	• 2008 Special Study 48 - Hacienda Sol Wash Floodplain Analysis • 2007 Special Study 49 - Diamond Bell Ranch Hydrology • 2008 Special Study 50 - Floodplain Study for Flecha Caida Ranch Estates #9 • 2008 Special Study 51 - Floodplain Analysis for Tanuri Wash • 2004 Special Study 52 - Emergency Evaluation Study Report on the July 29, 2003, Flooding in Ajo, Arizona • 2010 Special Study 53 - Floodplain Mapping of the Woodland Wash and its Tributaries • 2010 Special Study 54 - Floodplain Mapping of the Geronimo Wash and its Tributary • 2010 Special Study 55 - Flecha Caida LOMR Technical Data Notebook • 2010 Special Study 56 - Craycroft Wash Technical Data Notebook for Hydrologic and Hydraulic Mapping of the Craycroft Wash and its Tributary • 2010 Special Study 57 - Old Grandad Tank Technical Data Notebook for Hydrologic and Hydraulic Mapping of the Old Grandad Tank Wash and its Tributary • 2010 Special Study 58 - Wentworth Wash Technical Data Notebook for Hydrologic and Hydraulic Mapping of Wentworth Wash and its Tributary • 2010 Special Study 59 - Castle Rock Wash Technical Data Notebook for Hydrologic and Hydraulic Mapping of Castle Rock Wash and its Tributary • 2010 Special Study 60 - Trails End Wash Technical Data Notebook for Hydrologic and Hydraulic Mapping of Trails End Wash and its Tributary • 2011 Special Study 61 - Picture Rocks Technical Data Notebook for Hydrologic and Hydraulic Mapping • 2010 Special Study 62 - West Speedway Wash Technical Data Notebook for Hydrologic and Hydraulic Mapping • 2010 Special Study 63 - Camino de Oeste Wash Technical Data Notebook	

Table 5-1-1: Pima County Legal and Regulatory Capabilities		
Regulatory Tools for Hazard Mitigation	**Description**	**Responsible Department/Agency**
	for Hydrologic and Hydraulic Mapping • 2010 Special Study 64 - Del Cerro Wash Technical Data Notebook for Hydrologic and Hydraulic Mapping • 2010 Special Study 65 - Roger Wash Technical Data Notebook for Hydrologic and Hydraulic Mapping • 2010 Special Study 66 - Sweetwater Wash Technical Data Notebook for Hydrologic and Hydraulic Mapping • 2010 Special Study 67 - Unnamed Wash 1 Technical Data Notebook for Hydrologic and Hydraulic Mapping • 2010 Special Study 68 - Ventana Canyon Wash and Esperero Wash Technical Data Notebook for Hydrologic and Hydraulic Mapping	

Table 5-1-2: Pima County Technical Staff and Personnel Capabilities		
Staff/Personnel Resources	☑	**Department/Agency - Position**
Planner(s) or engineer(s) with knowledge of land development and land management practices	☑	Development Services, DOT, RFCD, Wastewater, Solid Waste, Natural Resources and Parks
Engineer(s) or professional(s) trained in construction practices related to buildings and/or infrastructure	☑	Development Services/ DOT / Wastewater
Planner(s) or engineer(s) with and understanding of natural and/or human-caused hazards	☑	Development Services / DOT / RFCD / Wastewater, Natural Resources and Parks, Health Department
Floodplain Manager	☑	RFCD / Dev Services
Surveyors	☑	DOT/ RFCD / Natural Resources and Parks
Staff with education or expertise to assess the community's vulnerability to hazards	☑	Dev Services, DOT, Facilities Management, Health, Comm Services, Sheriff, Natural Res/Parks, Risk Mgmt / RFCD
Personnel skilled in GIS and/or HAZUS	☑	Development Services, DOT, RFCD, Wastewater, Facilities Management. Sheriff, Natural Resources/Parks
Scientists familiar with the hazards of the community	☑	Health Department, Wastewater, Medical Examiner, Sheriff
Emergency manager	☑	OEM, Sheriff
Grant writer(s)	☑	OEM, Dev Services, Health Department, Cultural Resources

Table 5-1-3: Pima County Fiscal Capabilities

Financial Resources	Accessible or Eligible to Use (Yes, No, Don't Know)	Comments
Community Development Block Grants	Yes	
Capital Improvements Project funding	Yes	
Authority to levy taxes for specific purposes	Yes	
Fees for water, sewer, gas, or electric service	Yes	
Impact fees for homebuyers or new developments/homes	Yes	
Incur debt through general obligation bonds	Yes	
Incur debt through special tax bonds	Yes	

Table 5-2-1: Marana Legal and Regulatory Capabilities

Regulatory Tools for Hazard Mitigation	Description	Responsible Department/Agency
CODES	• Marana Town Code • Land Development Code • 2006 Int'l Building, Residential, Mechanical , Plumbing, Energy Conservation, Property Maintenance, and Fire Code • 2005 National Electrical Code	• Planning • Engineering • Fire
ORDINANCES, RESOLUTIONS	• Res 2003-141 – IGA with Pima County: Assist with Review & Update of Marana's Emergency Operations Plan • Res 2006-12 – Adopting of Emergency Operations Plan • Res 2006- 174 – Approving & Authorizing Pima Co Multi-Jurisdictional Hazard Mitigation Plan • Res 2010- 99 – Subgrantee for funding – 2010 State Homeland Security Program (references emergency operations in the 3rd paragraph) • Ordinance 85.05 – Enacting the Emergency Operations/Disaster Plan for Marana	• Police • Council • Town Manager
PLANS, MANUALS, and/or GUIDELINES	• Town of Marana Emergency Operations Plan 2006	• Police

Table 5-2-2: Marana Technical Staff and Personnel Capabilities

Staff/Personnel Resources	☑	Department/Agency - Position
Planner(s) or engineer(s) with knowledge of land development and land management practices	☑	Dept of Public Works, Subdivision Engineering Dept.
Engineer(s) or professional(s) trained in construction practices related to buildings and/or infrastructure	☑	Dept. of Public Works, Manager Construction Mgmt. Div.
Planner(s) or engineer(s) with and understanding of natural and/or human-caused hazards	☑	Dept. of Public Works, Manager Environmental Engineering Div.
Floodplain Manager	☑	Dept of Public Works, Subdivision Engineering Dept.
Surveyors	☑	GIS Dept
Staff with education or expertise to assess the community's vulnerability to hazards		
Personnel skilled in GIS and/or HAZUS	☑	GIS Dept./GIS Manager and Staff
Scientists familiar with the hazards of the community		
Emergency Management Coordinator	☑	Police Department
Grant writer(s)	☑	Community Development

Table 5-2-3: Marana Fiscal Capabilities

Financial Resources	Accessible or Eligible to Use (Yes, No, Don't Know)	Comments
Community Development Block Grants	Yes	
Capital Improvements Project funding	Yes	
Authority to levy taxes for specific purposes	Yes	
Fees for water, sewer, gas, or electric service	Yes	Fees for water
Impact fees for homebuyers or new developments/homes	Yes	
Incur debt through general obligation bonds	Yes	
Incur debt through special tax bonds	Yes	

Table 5-3-1: Oro Valley Legal and Regulatory Capabilities

Regulatory Tools for Hazard Mitigation	Description	Responsible Department/Agency
CODES	• 2006 Int'l Building, Residential, Plumbing, Mechanical, Energy Conservation, Property Maintenance, Fire and Gas Code • National Electrical Code (2005) • Americans with Disabilities Act Accessible Guidelines (1998) • Oro Valley Zoning Code, Revised (2011) • Oro Valley Town Code, Chapters 6, 7, 15 & 17	• Development and Infrastructure Services (DIS)
ORDINANCES	• Oro Valley Floodplain and Erosion Hazard Management Ordinance (2005) • Oro Valley Storm Water Management and Discharge Control Ordinance, Article 15-24 (2008) • Environmental Sensitive Lands Regulations, 27.10 • Zoning Code adopted by Ordinance includes: Hillside Development Zone, 24.2; and Airport Environs Zone, 24.8 (2011)	• Golder Ranch Fire District • DIS
PLANS, MANUALS, and/or GUIDELINES	• US Army Corps of Engineers, Federal Highway Administration, "State Standard 7-98 Watercourse Bank Stabilization" • Pima Co Multi-Jurisdictional Hazard Mitigation Plan (2007) • Pima Co DOT Stormwater Detention/Retention Manual • Oro Valley General Plan (2005) • Capital Investment Plan (2010) • Oro Valley Subdivision Street Standards • Pima County – City of Tucson Standard Specifications and Details for Public Improvement Projects (2006) • Tucson Standards Manual for Drainage Design and Floodplain Management • Tucson Design Manual • Storm Water Ready Plan • Drainage Criteria Manual (2010) • Drought Management Plan • Catalina Community Wildfire Protection Plan • Pima Co Navigable Waters and Flood Plains • Town Water Utility Drought Policy • Town Water Utility Emergency Response Plans	• Pima CoRegional Flood Control District • Tucson • Golder Ranch • DIS • Finance • Water Utility
STUDIES	• FEMA Flood Plain Maps (2011) • FEMA Flood Delineation Studies (1999) • Oro Valley Town Wide Drainage Study (2008) • Pima Co Flood Control District Flood Plain Studies • Canyon del Oro Wash LOMR (2008) • Lomas De Oro Wash (2008) • El Conquistador LOMR (2010) • Big Wash (OV marketplace LOMR) (2010)	• FEMA • Pima Co Regional Flood Control District • DIS

Table 5-3-1: Oro Valley Legal and Regulatory Capabilities

Regulatory Tools for Hazard Mitigation	Description	Responsible Department/Agency
	• Local Pima County Wash studies a) Arroyo Grande, 2009 b) Linda Vista/Logan's Crossing, 2010 c) Highlands Wash, 2011 • Evaluation of emergency routes	

Table 5-3-2: Oro Valley Technical Staff and Personnel Capabilities

Staff/Personnel Resources	☑	Department/Agency - Position
Planner(s) or engineer(s) with knowledge of land development and land management practices	☑	Development and Infrastructure Services
Engineer(s) or professional(s) trained in construction practices related to buildings and/or infrastructure	☑	Development and Infrastructure Services
Planner(s) or engineer(s) with and understanding of natural and/or human-caused hazards	☑	Development and Infrastructure Services Oro Valley Police Department Water Utility
Floodplain Manager	☑	Development and Infrastructure Services
Surveyors		
Staff with education or expertise to assess the community's vulnerability to hazards	☑	Development and Infrastructure Services Oro Valley Police Department Water Utility
Personnel skilled in GIS and/or HAZUS	☑	Development and Infrastructure Services
Scientists familiar with the hazards of the community		
Emergency manager	☑	Oro Valley Police Department
Grant writer(s)	☑	Various departments
Others	☑	Town staff trained in NIMS and ICS

Table 5-3-3: Oro Valley Fiscal Capabilities

Financial Resources	Accessible or Eligible to Use (Yes, No, Don't Know)	Comments
Community Development Block Grants	Yes	
Capital Improvements Project funding	Yes	
Authority to levy taxes for specific purposes	Yes	
Fees for water, sewer, gas, electric service, and stormwater	Yes	
Impact fees for homebuyers or new developments/homes	Yes	
Incur debt through general obligation bonds	Yes	
Incur debt through special tax bonds	Yes	

Table 5-4-1: Pascua Yaqui Tribe Legal and Regulatory Capabilities

Regulatory Tools for Hazard Mitigation	Description	Responsible Department/Agency
CODES	• IBC 2006 • IFC 2009 • NFPA Standards 2009	• Fire Department • Facilities and Housing Department
ORDINANCES	• Zoning Ordinance (similar to Pima Co) • Reference county and state ordinances	• Land Department/ Development Services
PLANS, MANUALS, and/or GUIDELINES	• Salt River Wildland Fire Management Plan (2011) • Pima Co Hazard Mitigation Plan (2007)	• Fire Department • Land Department/ Development Services
STUDIES	• Environmental and Floodplain Studies for new facilities. • Endangered Species List study	• Land Department/ Development Services

Table 5-4-2: Pascua Yaqui Tribe Technical Staff and Personnel Capabilities

Staff/Personnel Resources	☑	Department/Agency - Position
Planner(s) or engineer(s) with knowledge of land development and land management practices	☑	Land Department/Development Services – Director Procurement Department – Construction Manager
Engineer(s) or professional(s) trained in construction practices related to buildings and/or infrastructure	☑	Facilities and Housing Department – Director, Inspectors Procurement Department – Construction Manager
Planner(s) or engineer(s) with an understanding of natural and/or human-caused hazards	☑	Fire Department – Fire Chief
Surveyors		
Staff with education or expertise to assess the community's vulnerability to hazards	☑	Health Department – Risk Manager
Personnel skilled in GIS and/or HAZUS	☑	Land Department/Development Services – GIS Analyst
Scientists familiar with the hazards of the community		
Emergency manager	☑	Police Department – Police Chief
Grant writer(s)	☑	Tribal Grants/Contracts

Staff resources in several PYT departments and programs, working under the auspices of the tribal council, collectively provide hazard mitigation for the Tribe. The PYT also, when necessary, hires consultants or works with outside public agencies to conduct the necessary technical studies and analyses to determine both risk and mitigation alternatives.

Table 5-4-3: Pascua Yaqui Tribe Fiscal Capabilities

Financial Resources	Accessible or Eligible to Use (Yes, No, Don't Know)	Comments
Community Development Block Grants	Yes	
Capital Improvements Project funding	Yes	Developed based on availability of funds. Rolling 5-year basis.
Authority to levy taxes for specific purposes	Yes	
Fees for water, sewer, gas, or electric service	No	PYT does not have the legal capability to impose fees. These fees are all imposed by non-Tribal utility providers. The Tribe would have the authority to tax these utility service fees, but currently does not.
Impact fees for homebuyers or new developments/homes	No	PYT has the legal capability to impose fees but currently does not.
Incur debt through general obligation bonds	Yes	
Incur debt through special tax bonds	Yes	The Tribe has this capability, but the taxes collected by the Tribe are probably not sufficient, and never will be sufficient, to support bonds based upon those possible tax streams.

Current and past financial sources available to the Tribe for hazard mitigation planning and projects include potential disaster and mitigation funds through FEMA (Public Assistance, HMGP, and PDM funds), programs established through the Indian Self Determination Act (Public Law 93-638), casino and tribal enterprise revenues, and various departmental operation budgets. Other potential sources of funds may include the U.S. Department of Interior (Bureau of Reclamation, Bureau of Indian Affairs, U.S. Geological Survey, Bureau of Land Management), U.S. Army Corps of Engineers, U.S. Housing and Urban Development, U.S. Department of Health and Human Services (Indian Health Service), and the U.S. Department of Agriculture (U.S. Forest Service, Natural Resources Conservation Service), State of Arizona (Governor's Office of Economic Development, Arizona Department of Transportation, Arizona Department of Housing, Arizona Department of Health Services), Pima Association of Governments, and other federal, state and local sources.

Table 5-5-1: Sahuarita Legal and Regulatory Capabilities

Regulatory Tools for Hazard Mitigation	Description	Responsible Department/Agency
CODES	• Sahuarita Town Code - current through Ordinance 2011-051, passed March 28, 2011 • 2006 Series of International Codes (Chapter 15.05 of the Town Code) as amended • 2005 National Electric Code as amended	• Planning & Building Safety • Police • Public Works • Green Valley Fire District • Rural Metro Fire District
ORDINANCES	• Floodplain Management Ordinance (Chapter 14.05 of Town Code – Ord Nos. 2006-09 § 3, 2006-15 § 1, 2006-15 § 2, and 2006-15 § 3) • Aquifer Protection permit #103602	• Public Works • Water Reclamation

PLANS, MANUALS, and/or GUIDELINES	• Pima Co Hazard Mitigation Plan (2007)
	• Town of Sahuarita General Plan (2003)
	• Specific Plans
	  • Madera Highland (2003)
	  • Quail Creek (Amended 2000)
	  • Rancho Sahuarita (Revised 2010)
	• Sahuarita Town Center and Santa Cruz River Corridor Sub Area Plan (2008)
	• Strategic Plan for Economic Development (2009)
	• Capital Improvement Plan (5-Year Rolling Plan Updated Annually)
	• Strategic Plan for Emergency Preparedness 2011
		• Planning & Building Safety
		• Public Works
		• Police Dept

STUDIES	• None	• None

Table 5-5-2: Sahuarita Technical Staff and Personnel Capabilities

Staff/Personnel Resources	☑	Department/Agency - Position
Planner(s) or engineer(s) with knowledge of land development and land management practices	☑	Public Works Director, Planning Director, Building Official
Engineer(s) or professional(s) trained in construction practices related to buildings and/or infrastructure	☑	Public Works Director, Building Official
Planner(s) or engineer(s) with and understanding of natural and/or human-caused hazards	☑	Public Works Director, Planning Director, Building Official, Emergency Planner
Floodplain Manager	☑	Public Works Director
Surveyors	☑	Contract firm, Public Works Director
Staff with education or expertise to assess the community's vulnerability to hazards	☑	Public Works Director, Planning and Building Safety Director, Emergency Planner
Personnel skilled in GIS and/or HAZUS	☑	Contract Firm for Planning and Public Works Department

Table 5-5-2: Sahuarita Technical Staff and Personnel Capabilities

Staff/Personnel Resources	☑	Department/Agency - Position
Scientists familiar with the hazards of the community	☑	Public Works Director
Emergency manager	☑	Emergency Response Planner
Grant writer(s)	☑	Police Department, Public Works, Parks and Recreation Department, Office of the Town Manager

Table 5-5-3: Sahuarita Fiscal Capabilities

Financial Resources	Accessible or Eligible to Use (Yes, No, Don't Know)	Comments
Community Development Block Grants	Yes	
Capital Improvements Project funding	Yes	Multi-year CIP Program to include Sahuarita Road redevelopment including pedestrian underpass
Authority to levy taxes for specific purposes	No	None
Fees for water, sewer, gas, or electric service	Yes	Sewer connection/hook-up fees, no other for Town
Impact fees for homebuyers or new developments/homes	No	None, see "other" below
Incur debt through general obligation bonds	Yes	Only when necessary
Incur debt through special tax bonds	No	None
Other/Construction Sales Tax	Yes	Levied for each new home built in community

Table 5-6-1: Tucson Legal and Regulatory Capabilities

Regulatory Tools for Hazard Mitigation	Description	Responsible Department/Agency
CODES	• 2006 IBC with local amendments (w/la) • 2006 Tucson Building Code (w/la) • 2003 ICC/ANSI A 117.1 (w/la) • 2006 IRC (w/la) • 2006 IEBS (w/la) • 2006 IECC (w/la) • 2006 IMC (w/la) • 2006 IFGC (w/la) • 2006 IFC (w/la) • 2006 IPC (w/la) • 2005 National Electrical Code/NFPA-70 (w/la) • 2006 IPC (w/la) • Tucson Land Use Code	• Development and Planning Services
ORDINANCES	• Tucson Code of Ordinance	• City Manager
PLANS, MANUALS, and/or GUIDELINES	• Pima Co Multi-Jurisdictional Hazard Mitigation Plan (2007) • 2001 Tucson General Plan (beginning revision) • 2007 Tucson Emergency Operations Plan • 2004 Design Standards Manual for Water • National Flood Insurance Program (NFIP) Regulations • 2005 Supplement to the PAG Uniform Standard • Third-party Plan Review Policies and Standards	• City Manager • COT Office of Emergency Mgt. & Homeland Security • Pima Co COTOEMHS • Tucson Water • Tucson Fire • Pima Assoc of Gov'ts • Various Depts
STUDIES	• FEMA DFIRM Maps • Dam Safety Studies and Emergency Action Plans • Flood Insurance Studies (FIS)	• Development & Planning Services • Parks & Recreation • Development & Planning Services

Table 5-6-2: Tucson Technical Staff and Personnel Capabilitites

Staff/Personnel Resources	☑	Department/Agency - Position
Planner(s) or engineer(s) with knowledge of land development and land management practices	☑	Planning Dept. – Principal Planner, Planner II, Planner III Water Services – Superintendents, Project Engineers, Civil Engineers, Project Coordinators, Principal Engineering Technicians, Principal Planners
Engineer(s) or professional(s) trained in construction practices related to buildings and/or infrastructure	☑	Street Transportation Dept. - Civil Engineers Water Services – Superintendents, Civil Engineers, Project Coordinators, Principal Engineering Technicians
Planner(s) or engineer(s) with and understanding of natural and/or human-caused hazards	☑	Planning Dept. – Principal Planner, Planner II, Planner III Water Services – Superintendents, Civil Engineers, Principal Engineering Technician, Hydrologist
Floodplain Manager	☑	Street Transportation Dept. - Civil Engineer III
Surveyors	☑	Street Transportation Dept. – Survey Teams
Staff with education or expertise to assess the community's vulnerability to hazards	☑	Water Services – Environmental Programs Coordinator, Civil Engineers, Water Quality Inspectors
Personnel skilled in GIS and/or HAZUS	☑	Information Technology Services – Info Tech Analyst/Programmers and Info Tech Specialists Fire Dept. – Fire Protection Engineer Police Dept. – Senior User Technology Specialist Street Transportation Dept. - Info Tech Analyst/ Programmer II and Senior GIS Technician Water Services Dept. – GIS and Senior GIS Technicians
Scientists familiar with the hazards of the community	☑	Office of Environmental Programs – Environmental Quality Specialists Water Services – Chemists, Environmental Quality Specialist, Laboratory Technician, Environmental Programs Coordinator
Emergency manager	☑	Tucson Office of Emergency Management
Grant writer(s)	☑	Fire Dept. – Fire Captains and Grant Manager Planning Dept. – Principal Planner, Planner II, Planner III Police Dept. – Police Research Analysts Public Transit, Division of Transportation

Table 5-6-3: Tucson Fiscal Capabilities

Financial Resources	Accessible or Eligible to Use (Yes, No, Don't Know)	Comments
Community Development Block Grants	Yes	Housing, Community Services, and Water Services projects
Capital Improvements Project funding	Yes	
Authority to levy taxes for specific purposes	Yes	
Fees for water, sewer, gas, or electric service	Yes	Water and Solid Waste Fees
Impact fees for homebuyers or new developments/homes	Yes	For new developments inside impact fee areas-zones only. The Impact Fees are charged to new developments.
Incur debt through general obligation bonds	Yes	This excludes the Water Department
Incur debt through special tax bonds	Yes	Excise (sales) taxes

Tribal Pre- and Post Disaster Hazard Management

In addition to Tables 6-1-4, 6-2-4, and 6-3-4, the Pascua Yaqui Tribe is required to summarize and evaluate pre- and post-disaster hazard management to satisfy the §201.7 Tribal Planning capability assessment requirements. Accordingly, Table 6-4 summarizes hazard mitigation and pre- and post-disaster hazard management practices and roles that are currently accomplished through several Pascua Yaqui Tribe departments and programs.

Table 5-7: Mitigation Responsibilities for the Pascua Yaqui Tribe

Department or Agency	Hazard Mitigation and/or Disaster Management Activities
Office of the Chairman	• General emergency oversight • General development oversight
Tribal Council	• Final approval for all pre-disaster planning, projects and funding allocation for pre- and post-disaster hazard management activities.
Land Department	• Regulates land use and development including zoning and flood management. • Lead planning department for all tribal development including flood control, transportation, and other physical improvements on the reservation.
Fire Department	• Shared emergency management role with Police Department • Emergency response and mitigation responsibilities regarding fire and HazMat. • Hazmat awareness and operations, but not technical response for removal or clean-up. • Wildland fire awareness and operations • CERT Team collaboration • Part of the AZ Mutual Aid Compact (AZMAC) • (Pima County Fire Chiefs mutual aid agreement, pending)
Health Department	• Control of disease and outbreak incidents • Dispensing of medication and anti-viral vaccines through points of distribution and points of dispensing. • Public awareness and public service announcements in collaboration with the local radio station. • Conduct training for hazard related issues and incidents • CERT Team collaboration
Police Department	• Shared emergency management role with Fire Department • Response and mitigation for many of the human-caused hazards related to the civil population and terrorism • Enforcement of tribal law • Participates in a regional SWAT team
Facilities Management	• Maintain and operate heavy equipment for response to disaster related needs • Maintain electricians on staff • Responsibility for emergency shut-off of water mains • Maintain a 24/7 on-call capability
Procurement Department	• Emergency and other purchases • Maintenance of emergency generators
Indian Health Services – Office of Engineering and Environmental Health	• Emergency response and post-disaster needs assessments for mitigation and recovery.
BIA	• Mutual aid cooperative agreement with PYT for fire response and financial assistance.

The Pascua Yaqui Tribe has several programs and policies in-place to provide for effective hazard mitigation, as is summarized in Tables 6-1-4, 6-2-4, 6-3-4 and 6-4. The Tribal Planning Team performed an evaluation/assessment of the information summarized in Tables 6-1-4, 6-2-4, 6-3-4 and 6-4, and noted the following regarding successes, gaps, opportunities and changes over the last plan cycle:

- Regarding pre- and post-disaster hazard management policies, programs, and capabilities, the tribal planning team:
  - Identified a need for the development of an emergency response plan.
  - Identified a need for additional resources to adequately respond to a human-caused incident at the AVA entertainment facility and casino.
  - Found that the current mutual aid agreements were proving effective in providing additional response capacity
  - The management of flood related hazards is by far the most prominent hazard mitigation need for the Tribe due to the reservation being wholly situated within a 100-year floodplain and subject to regular flooding. There is a serious need for flood control related funding and projects.
- There has been no significant change in the Tribe's policies related to development in hazard prone areas over the 2007 Plan cycle other than to regulate to the 100-year floodplain using the data and recommendations of the Master Drainage Study summarized in Table 7-1 (See Section 7.3 of this Plan).
- Specific hazard management capabilities of the tribe that have changed since approval of the previous plan include:
  - New BIA, Pima Fire Chiefs, and SWAT cooperative/mutual aid agreements have been developed.
  - The Master Drainage Plan summarized in Table 7-1 was completed and became available for flood management use.
  - CERT teams newly were organized in 2008

Upon receipt of a presidential disaster declaration, the Tribe will work with FEMA to develop two post-disaster hazard management tools: 1) a Public Assistance Administration Plan, and; 2) a Hazard Mitigation Grant Program Administration Plan. Both plans will be used by the Tribe to identify the roles and responsibilities of the Tribe in administering the FEMA Public Assistance (PA) and Hazard Mitigation Grant Programs (HMGP), and to outline staffing requirements and the policies and procedures to be used. A result of developing these plans, as well as preparing this Plan, will be to further focus Tribal resources on the importance of hazard management and mitigation planning.

Previous Mitigation Activities

During the last planning cycle many mitigation activities have been accomplished by the jurisdictions within Pima County. Table 6-5 provides an updated summary, by jurisdiction, of recent mitigation activities performed over the last planning cycle or generally within the last five to ten years. Table 6-6 identifies projects within Pima County that used federal mitigation grant funding for past projects.

Table 5-8: Previous Mitigation Projects Receiving Federal Mitigation Funding

Applicant	Project Title	Project Type	Timeframe	Total Cost (x $1,000)	Federal Cost Share	Non-Federal Cost Share	Program
Pima Co	977-11, Emergency Rapid Response	EOC upgrade	1997-2000	$47,000.00	$35,250.00	$11,750.00	HMGP
Pima Co	977-15, Video Down Link (5%)	Down link from airborne source to EOC	1998-2001	$130,000.00	$97,500.00	$32,500.00	HMGP
Pima Co	977-24, Mitigation Plan (5%)	Mitigation Plan	1998-2001	$134,000.00	$100,500.00	$33,500.00	HMGP

5.3 Mitigation Actions/Projects

Mitigation actions/projects (A/P) are those activities identified by a jurisdiction, that when implemented, will have the effect of reducing the community's exposure and risk to the particular hazard or hazards being mitigated. The implementation strategy addresses the "*how, when, and by whom?*" questions related to implementing an identified A/P.

The process for defining the list of mitigation A/Ps for the Plan was accomplished in three steps. First, an assessment of the actions and projects specified in Section 6.4 of the 2007 Plan was performed, wherein each jurisdiction reviewed and evaluated their jurisdiction's specific list. Second, a new list of A/Ps for the Plan was developed by combining the carry forward results from the assessment with new A/Ps. Third, an implementation strategy for the combined list of A/Ps was formulated. Details of each step and the results of the process are summarized in the following sections.

Previous Mitigation Actions/Projects Assessment

The Planning Team and Local Planning Team for each jurisdiction reviewed and assessed the actions and projects listed in Tables 6-27 through 6-33 of the 2007 Plan. The assessment included evaluating and classifying each of the previously identified A/Ps based on the following criteria:

Status		**Disposition**	
Classification	Explanation Requirement:	Classification	Explanation Requirement:
"**No Action**"	Reason for no progress	**"Keep"**	None required
"**In Progress**"	What progress has been made	**"Revise"**	Revised components
"**Complete**"	Date of completion and final cost of project (if applicable)	**"Delete"**	Reason(s) for exclusion.

Any A/P with a disposition classification of "Keep" or "Revise" was carried forward to become part of the A/P list for the Plan. All A/Ps identified as "Delete" were removed and are not carried forward in this Plan. The results of the assessment for each of the 2007 Plan A/Ps is summarized by jurisdiction in Tables 6-8-1 through 6-8-6.

New Mitigation Actions

Upon completion of the assessment summarized in Section 6.3.1, each jurisdiction's Local Planning Team developed new A/Ps using the goals and objectives, results of the vulnerability analysis and capability assessment, and the planning team's institutional knowledge of hazard mitigation needs in the community. The A/Ps can be generally classified as either structural or non-structural. Structural A/Ps typify a traditional "bricks and mortar" approach where physical improvements are provided to effect the mitigation goals. Examples may include forest thinning, channels, culverts, bridges, detention basins, dams, emergency structures, and structural augmentations of existing facilities. Non-structural A/Ps deal more with policy, ordinance, regulation and administrative actions or changes, buy-out programs, and legislative actions. For each A/P, the following elements were identified:

- **Description** – a brief description of the A/P including a supporting statement that tells the "what" and "why" reason for the A/P.
- **Hazard(s) Mitigated** – a list of the hazard or hazards mitigated by the A/P.
- **Estimated Cost** – concept level cost estimates that may be a dollar amount or estimated as staff time.
- **Anticipated Completion Date** – a realistic and general timeframe for completing the A/P. Examples may include a specific target date, a timeframe contingent upon other processes, or recurring timeframes.
- **Lead Agency** – the agency, department, office, or other entity and corresponding job title that will have responsibility for the A/P and its implementation.
- **Funding Source** – the source or sources of anticipated funding for the A/P.

- **Priority Ranking** – each A/P was assigned a priority ranking of either "High", "Medium", or "Low". The assignments were subjectively made using a simple process that assessed how well the A/P satisfied the following considerations:
  - A favorable benefit versus cost evaluation, wherein the perceived direct and indirect benefits outweighed the project cost.
  - A direct beneficial impact on the ability to protect life and/or property from natural hazards.
  - A mitigation solution with a long-term effectiveness

Tables 6-9-1 through 6-9-6 summarize the current mitigation A/P and implementation strategy for each participating Plan jurisdiction. Projects listed in *italics font* are recognized as being more response and recovery oriented, but are considered to be a significant part of the overall hazard management goals of the community. No Tables 6-9-xx are provided for South Tucson or the Tohono O'odham Nation.

Table 5-9-1: Mitigation Measures for Pima County

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Enforce Flood & Erosion Hazard Ordinance in accordance with the NFIP.	Flood	Both	$1.2 million	High	Regulatory	On going	RFCD / Floodplain Management Division	Flood Control tax Levy
Implement NFIP tasks such as LOMR submittals, maintaining a county-wide map repository, performing master drainage studies, and coordinating to insure the digital map is correct.	Flood	Both	$600,000	High	Regulatory	On going	RFCD / Planning & Development Division	Flood Control Tax Levy
Arroyo Chico Multi-Use Project – Phase 2B (Basins 1, 2 & 3)	Flood	Both	$13.3 million	High	CIP	September, 2013	RFCD / Engineering Division	Flood Control Tax Levy & USACOE
Inspection and preventative maintenance on levees as needed.	Levee Failure	Both	$50,000	High	Levee Operation & Maintenance Manual	On going	RFCD / Infrastructure Management Division	Flood Control Tax Levy
Develop and implement multi-agency exercises and drills related to outbreaks of communicable illnesses and vector control.	*Disease (Response)*	*(Response)*	*Staff Time*	*High*	*Departmental Plans*	*12 months*	*Health Department, Director*	*Grant Funds*
Develop a Shelter in Place Plan (appendix to Pima County Emergency Operations Plan).	*All (Response)*	*(Response)*	*Staff Time*	*High*	*Departmental Plans*	*24 months*	*Pima County Office of Emergency Management and Homeland Security, Director*	*Grant Funds (as available)*
Participate in Community Rating System to reduce insurance premiums.	Flood	Both	$50,000	Medium	N/A	On going	RFCD / Planning & Development Division	Flood Control Tax Levy

Table 5-9-2: Mitigation Measures for Marana

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	Hazard(s) Mitigated	Community Assets Mitigated (Ex/New)	Estimated Cost	Priority Ranking	Planning Mechanism(s) for Implementation	Anticipated Completion Date	Primary Agency / Job Title Responsible for Implementation	Funding Source(s)
Provide training to the applicable Town of Marana departments on the adopted hazard mitigation plan and its requirements.	All	Both	$500	High	(None identified)	2012	Emergency Management Coordinator	General Fund
Conduct a public education campaign to increase awareness of natural hazards by distributing ADEM and Pima County mitigation flyers at community events and public gathering opportunities, as appropriate. This will be accomplished semi-annually by Community Services.	All	Both	$500	High	(None identified)	2014	Community Development Director	General Fund
The Town of Marana will continue to plan for, design, and construct appropriate flood control structures for public safety and damage reduction.	Flood	Both	$133M	High	CIP	2018	Development Services/ General Manager	Grants, Transportation General Fund, Bonds, etc
Encourage bridge or culvert construction where roads are susceptible to flooding. This will be accomplished as part of the Planning Process when Developers apply to build in Marana.	Flood	Both	Staff Time	High	(None identified)	2016	Development Services/ General Manager	General Fund
The Town of Marana will continue to participate in the National Flood Insurance Program by reviewing applications for buildings, ensuring they are properly designed.	Flood	Both	Staff Time	High	(None identified)	2016	Development Services/ General Manager	General Fund
Rattlesnake Pass from Saguaro Springs to Twin Peaks Road.	Flood	Existing	$29.8 Million	High	CIP	2018	Public Works / Director	Transportation Fund, General Fund
Barnett Linear Park and Flood Control – Construct a 3-mile channel along Barnett Road to mitigate the drainage and flood hazard from the Santa Cruz River	Flood	New	$16.5 Million	High	CIP	2016	Public Works / Director	General Fund, Future MMPC Bonds

Table 5-9-2: Mitigation Measures for Marana

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Ina Road Bridge – Remove and replace the Ina Road bridge that crosses the Santa Cruz River	Flood	New	$17.5 Million	High	CIP	2016	Development Services / Director	Transportation Fund, HURF Bonds, General Fund
Ina Road Improvements from Silverbell Road to I-10 – widening of Ina Road to 4-lane section with raised median, sidewalks, and drainage improvements	Flood	New	$16.5 Million	High	(None identified)	2016	Public Works/Director	Transportation Fund, Federal Grants
Tangerine Road Corridor - provide a minimum of 4 lanes with raised medians, drainage improvements, sidewalks, ADA facilities, multi-use path and lanes, Traffic Signals, Right-of-Way acquisitions, Utility relocations, Marana Water line extensions, and sewer modifications and additions.	Flood	New	$95.5 Million	High	CIP	2019	Public Works / Director	RTA, Future Bond Money
Ina Road TI – lower I-10 and construct a new overpass that will span both I-10 and the UPRR tracks. Project will mitigate flood issues and also improve access that will reduce accidents and HAZMAT incidents	Flood, HAZMAT, Traffic Accidents	Existing	$65.0 Million	High	ADOT 5-Year Plan and RTA Plan	2018	Public Works / Director in coordination with ADOT	ADOT, RTA
UPRR and Tangerine Road	Wildfire, HAZMAT	New	$133,200	Medium	(None identified)	N/A	Utility Department / Director	Grant Funding
The Town of Marana will continue to participate in the Flood Prone Land Acquisition Program so we acquire properties located in flood hazard areas.	Flood	Existing	Staff	Medium	NFIP Compliance	2016	Development Services/ General Manager	Grants, Partnership w/ Pima County

Table 5-9-3: Mitigation Measures for Oro Valley

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Develop, implement, and update a mass evacuation strategy for Oro Valley (including training and exercising).	*All (Response)*	*(Response)*	*Staff Time*	*High*	*Town wide emergency management program*	*Annually, ongoing*	*Emergency Management and DIS*	*General Fund and grant*
Develop, implement, and regularly update a Shelter in Place educational program (including training and exercising).	*All (Response)*	*(Response)*	*Staff Time*	*High*	*Town-wide emergency management program*	*Annually, ongoing*	*Emergency Management*	*General Fund and grant*
West Nile Virus Program Continued testing of mosquitoes for West Nile Virus. If a positive result, the area is sprayed.	Disease	Both	$5,000	High	IGA with Pima County Health Dept.	Annually, ongoing	Stormwater Utility	Pima County Health Dept.; Stormwater Utility, and Arizona Dept. of Health Zoonotic Diseases
Buffelgrass Program actively educates and removes buffelgrass in public areas across the Town.	Wildfire	Both	Staff and Volunteer Time	High	Buffelgrass Eradication Plan	Annual, ongoing	DIS	General Fund, grant, and volunteer time
Regularly update wildland-urban interface plans and educate communities about fire hazards.	Wildfire	Both	Staff Time	High	Wildland Urban Interface	Annual, ongoing	Golder Ranch Fire District	Golder Ranch
Widening of Lambert Lane between Pusch View Lane Bridge and La Canada Dr. will include drainage improvements to eliminate roadway flooding and debris.	Flood	Both	$8M	High	DIS Engineering	Sept. 2013	DIS	Pima Association Governments
Public education and outreach about protecting pipes and irrigation systems from freezes.	Extreme Temperature, Winter Storms	Both	Staff Time	High		Annual, ongoing	Oro Valley Water Utility	Water Utility Fees

Table 5-9-3: Mitigation Measures for Oro Valley

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Applicable Hazmat training and exercising for first responders; as well as participation in multi-agency regional hazmat and decontamination teams.	HAZMAT	Both	Staff Time and Training Costs	High		Annual, ongoing	Oro Valley Police Department and Golder Ranch	General Fund and Grant Funds
Town Cistern Project includes the addition of cisterns across the Town campus, water collected will be used for Town landscaping. Landscaping will be planned around the xeriscaping concept.	Drought	Both	$12,000	High	TOV Conservation and Sustainability Program	Annual, ongoing	DIS, Water, and Parks	General Fund and Private Funds
Continue to develop, expand, and implement a Drought Response Plan to address potential or long-term drought conditions.	Drought	Both	Staff Time	High	Water Utilty Drought Response Plan (currently in draft form)	Annual, ongoing	Water Utility	General Fund
Town of Oro Valley Stormwater Utility will continue to Manage Public Information Activities. • Monitor and maintain elevation certificates • Provide FEMA map information service • Conduct outreach projects to increase public awareness of flooding hazard promote flood insurance in general • Provide Flood protection information	Flood	Both	Staff Time and SW Utility Fees	Medium	NFIP CRS* Criteria and Guidelines	Annually ongoing	Storm Water Utility, EM, Permitting Div., TOV Library	Storm Water Utility Fees
Conduct Floodplain Mapping and Regulatory Activities. • Manage/prepare LOMCs* for FEMA designated floodplains • Generate and collect additional (local) floodplain maps and information • Promote and enforce open space preservation • Enforce and augment regulatory floodplain standards • Manage town wide floodplain data • Oversee stormwater management program	Flood	Both	Staff Time and SW Utility Fees	Medium	NFIP CRS, ESLO	Annually ongoing	Storm Water Utility	Storm Water Utility Fees

Table 5-9-3: Mitigation Measures for Oro Valley

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Conduct Flood Damage Reduction Activities • Organize floodplain management planning doc. • Investigate acquisition and relocation of flood prone properties • Conduct and manage drainage system maintenance	Flood	Both	Staff Time and SW Utility Fees	Medium	NFIP CRS, SW Maintenance SOP	Annually ongoing	Storm Water Utility	Storm Water Utility Fees
Conduct Flood Preparedness Activities • Coordinate flood warning program w/PCRFCD • Monitor levee safety for OV's certified levee	Flood	Both	Staff Time	Medium	NFIP CRS	Annually ongoing	Storm Water Utility	Storm Water Utility Fees
Oro Valley Emergency Management will provide training to applicable Town staff on the adopted hazard mitigation plan and its requirements.	All	Both	Staff Time	Medium	Town-wide emergency management program	Annually, ongoing	All Town Departments and Emergency Management	General Fund and grant
Review existing Oro Valley General Plan and zoning code to determine how these documents help limit development in hazardous areas. Modify with additional guidelines, regulations, and land use techniques as necessary within the limits of state statues, while also respecting private property rights.	All	Both	Staff Time	Low (due to annual review)	Town procedures	Annually, ongoing	DIS	General Fund

Table 5-9-4: Mitigation Measures for Pascua Yaqui Tribe

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Review existing building codes to determine adequate protection for new development in hazard areas. Where feasible and necessary, modify codes to help mitigate hazards imposed on such development within the limits of the Pascua Yaqui Reservation, while also respecting private property rights adjacent to the Reservation.	Drought, Earthquake, Flood, Severe Wind	Both	Staff	High	Follow community development plan	Ongoing and Continuous	*Land Development *Tribal Council	General Fund
Continued coordination between Pascua Yaqui Tribe, Pima County departments, municipalities, Pima Association of Governments, and other agencies in the development and maintenance of accurate geographic information system information for those hazard areas identified in the adopted hazard mitigation plan.	All	Both	Staff	High	Follow community development plan	Ongoing and Continuous	*Land Development *Tribal Council	General Fund
Develop a Mass Evacuation strategy for Pascua Yaqui Tribe and formalize in a published document	*All*	*Both*	*Staff time*	*High*	*In cooperation with ADEM Tribal Liaison will conduct a public education campaign to increase awareness of natural hazards by distributing ADEM mitigation flyers at public events*	*Continuing*	**Fire & Police Departments *Land and Procurement Departments*	*General Fund*
Continue the existing intergovernmental agreement between the Tribe and the State Forestry Department for assistance in the provision of emergency services within each other's jurisdictions.	*Wildfire*	*Both*	*Staff time*	*High*	*Annual Review*	*Continuing*	**Fire Department *Attorney General's Office *Tribal Council*	*General Fund*

Table 5-9-4: Mitigation Measures for Pascua Yaqui Tribe

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Conduct and enhance environmental and epidemiological surveillance activities in those areas identified as being of high public health importance and related to environmental factors such as; food safety and protection and vector control activities. Surveillance activities must include the identification of vulnerabilities and environmental factors that may contribute to the transmission of the communicable diseases associated with the operation and presence of these facilities in the Pascua Yaqui Tribe, as well as the implementation of preventative action which may be applied to reduce or eliminate the potential for transmission of communicable illnesses. Develop and improve the system of coordination and communication of these findings, trends and observations with other federal, state and local agencies that have similar or related interest.	Disease	Both	N/A	High	PYT PHEP Program currently has an IGA with ADHS for PHEP (Public Health Emergency Preparedness) for epidemiological surveillance activities high risk of communicable diseases and investigation opportunities of outbreaks. With Indian Health Service we have our environmental factors such as; food safety and protection of the environment on the PYT reservation. The PYT PHEP Program has a strong collaboration and communication with ADEM, ADHS, Pima County Health Department and the Tucson I.H.S.(Indian Health Services).	Ongoing	*Epidemiology Center Director	General Fund

Table 5-9-5: Mitigation Measures for Sahuarita

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Promote Child Drowning Prevention programs throughout the Town.	Drowning	Both	$3,000 and staff time	High	N/A	May 2012	Police Communications	Open
Continued adherence to AAC R18-9 for reductions in pollutant discharge at Town Aquifer.	HAZMAT	Existing	$15,000	High	Waste Water	March 2012	Public Works	Waste Water Fund
Updating of Waste Water Department contingency and emergency plans	HAZMAT	Both	Staff time	High	Waste Water	March 2012	Public Works	None
Continue annual updating of Town Storm water/Flooding Pollution Prevention Plan	Flood	Existing	Staff Time	High	Water Master Plan	January 2013	Public Works	None
Continue use of permit process from Corp of Engineers to streamline maintenance and bank stabilization efforts when needed	Flood	Existing	Staff Time	High	Army Corp	On going	Public Works	HERF Funds
Southern Arizona Buffelgrass removal mapping	Wildfire	Both	Staff Time	High	NA	May 2012	Public Works	T.O. Nation Grant
Implement Vector Borne Illness prevention program through mosquito abatement	Disease (Pandemic)	Both	$10,000	High	NA	September 2012	Public Works Parks and Rec	General Fund
Updating of riparian ordinance to protect various species that reduces erosion to mitigate flooding potentials and also reduces development in flood prone areas	Flood	Existing	$300 and staff time	Medium	NA	December 2011	Planning and Zoning	General Fund

Table 5-9-5: Mitigation Measures for Sahuarita

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Continued Controlled Burns on Town Property	Wildfire	Exiting	$2,000 and staff time	Medium	Green Valley Fire	January 2012	Fire Department Public Works	General Fund
Review, Update and Modify NFIP requirement and make appropriate modifications to Flood Plain Ordinance	Flood	Both	Staff Time	Medium	FEMA PCRFC	January 2013	Public Works	None
Educate the public to increase awareness of hazards, and potential opportunities for mitigation actions. Make Pima County's public information material sheets, websites, mitigation brochures, and media outlets available.	All	Both	Staff Time	Medium	Emergency Preparedness Strategic Plan	July 2012	Emergency Management	None
Landscape code amendment requiring vegetation adjustment in developed areas to reduce the heat island effect	Extreme Temperatures	Existing	$300 and staff time	Medium	None	December 2011	Planning and Zoning	General Fund
Develop and Implement internal emergency response procedure	*All (Response)*	*(Response)*	*Staff Time*	*Medium*	*NA*	*May 2012*	*Public Works*	*None*
Improve upon existing capabilities to warn the public of emergency situations by initiating a system to test the ability of local emergency managers to activate the AENS systems.	*All (Response)*	*(Response)*	*$5,000*	*Medium*	*Emergency Management Committee*	*January 2013*	*Emergency Management*	*General Fund*
Develop and Implement an interoperable communications between all emergency-related departments	*All (Response)*	*(Response)*	*Staff Time*	*Medium*	*N/A*	*January 2013*	*Emergency Management, Local Fire District*	*None*

Table 5-9-6: Mitigation Measures for Tucson

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Identify funding source and construct two bridges and 50 box culverts with 380 back-up power units for signalized intersections at high flood hazard crossings in City of Tucson limits in accord with the COT Department of Transportation 5-year plan. If a box culvert cannot be constructed an automated warning device, consisting of a barricade, signs and flashing lights would be installed.	Flood, Severe Wind	Both	$100 million, Staff Time	High	CIP	Ongoing effort with long-term horizon. Schedule dependent upon funding	Department of Transportation / Streets Administrator and Streets Chief Engineer	Grant Funds
Tucson Water, a division of the Utility Services Department, will secure its assets and facilities by implementing actions, in phases, as identified in the Federally mandated Water System Vulnerability Assessment completed in October 2002.	Terrorism, Vandalism	Existing	$20 million	High	Water System Vulnerability Assessment	On-going with full completion by 2020	Water Department / Water Engineer & Operations	Operations Budget
Promote disaster-resistant water delivery system by constructing redundant water transmission lines (e.g. The Utility and the community will be less susceptible to loss of water delivery due to natural or man-made disasters).	All	Both	$7.9 million	High		On-going with full completion by 2020	Water Department / Water Administrator Maintenance & Operations	Operations Budget
Work with the Arizona Geological Society and U.S. Geological Survey on projects that mitigate geo-hazards (e.g. Continue the feasibility study with the AZ Geological and U.S. Geological Surveys Water Plan 2000-2050.Construct second recharge facility to be known as the Southern Avra Valley Recharge and Recovery Project (SAVSARP). The utility could then use its entire allotment of Central Arizona Project water and provide capacity for recharging additional water supplies. Construction will take 5 years).	Drought, Earthquake, Subsidence, other geo-hazards.	Both	$51.2 million	High		Ongoing effort with long-term horizon. Schedule dependent upon funding	Water Department / Staff	Operations Budget

Table 5-9-6: Mitigation Measures for Tucson

GOAL: Reduce or eliminate the risk to people and property from natural and human caused hazards.
Objective 1: Reduce or eliminate risks that threaten life and property in the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 2: Reduce risk to critical facilities and infrastructure from natural and human caused hazards.
Objective 3: Promote hazard mitigation throughout the incorporated, unincorporated, and Tribal jurisdictions within Pima County.
Objective 4: Increase public awareness of hazards and risks that threaten the incorporated, unincorporated, and Tribal jurisdictions within Pima County.

Mitigation Action/Project				Implementation Strategy				
Description	**Hazard(s) Mitigated**	**Community Assets Mitigated (Ex/New)**	**Estimated Cost**	**Priority Ranking**	**Planning Mechanism(s) for Implementation**	**Anticipated Completion Date**	**Primary Agency / Job Title Responsible for Implementation**	**Funding Source(s)**
Re-direct drainage canal at Barrio Viego to prevent continued repetitive losses.	Flood	Both	$425,000	High		2013	Transportation Dept / Project Administrator	Grant Funds, General Fund, PCRFCD
In compliance with the NFIP, the City of Tucson will continue to require the preparation and submittal of a CLOMR or CLOMR-F for all proposed development within FEMA delineated Special Flood Hazard Areas	Flood	Both	Staff Time	High	Floodplain Ordinance	Annual - Ongoing	Development and Planning Services Department / Director	Department Budget and Fees for Developers
The Town of Tucson will maintain compliance with NFIP regulations by enforcement of the current floodplain management ordinance through review of new development located in the floodplain and issuance of floodplain use permits.	Flood	Both	Staff Time	High	Floodplain Ordinance	Annual - Ongoing	Development and Planning Services Department / Director	Department Budget
Improve floodplain administration under the NFIP program by sending inspectors into the field when we receive a flood warning from the National Weather Service, to assess bridges, washes and other critical infrastructures within the City of Tucson.	Flood	Both	Staff Time	High	Best Practices	Annual- Ongoing	Development and Planning Services Department / Director	Department Budget and Information

SECTION 6: PLAN MAINTENANCE PROCEDURES

Elements of this plan maintenance section include:

Monitoring and Evaluating the Plan

Updating the Plan

Incorporation into Planning Mechanisms

Continued Public Participation

Pima County and the participating jurisdictions recognize that this hazard mitigation plan is intended to be a "living" document with regularly scheduled monitoring, evaluation, and updating.

Section 7 of the 2007 Plan outlined specific steps for plan maintenance. A poll of the Planning Team indicated that few formal reviews or maintenance occurred over the past five years. The 2007 Plan was referenced / reviewed by the county for the identification and development of mitigation grant applications during the 2006 flooding disaster declaration and again in 2010 for buffelgrass mitigation actions/projects. The Town of Oro Valley also reviewed the 2007 Plan as a regular part of their HMGP application investigations. Reasons for the otherwise lack of formal review were discussed by the Planning Team, and included:

- Lack of funding and staff time available to allocate to the task
- Perceived lack of practicality and or usefulness beyond keeping eligible for grants.
- Lack of a Plan champion within each community
- Staffing changes / turnover wherein the maintenance requirements and even existence of the Plan was not communicated
- Lack of Plan awareness by departments outside of the emergency management community.

Recognizing the need for improvement, the Planning Team discussed ways to make sure that the Plan review and maintenance process will occur over the next five years. The results of those discussions are outlined in the following sections and the plan maintenance strategy.

6.1 Monitoring, Evaluation and Updating

Switching to a true multi-jurisdictional plan will aide in the Plan monitoring and evaluation by the consolidation of information for all county jurisdictions into one document. The Planning Team has established the following monitoring and evaluation procedures:

- **Schedule** – The Plan shall be reviewed on at least an annual basis or following a major disaster. The Pima Co Office of Emergency Management and Homeland Security (PCOEMHS) will take the lead to reconvene the Planning Team on or around the anniversary of the official FEMA Plan adoption date
- **Review Content** – One month prior to the Planning Team review meeting, a reminder questionnaire will be distributed to each jurisdictions' Point of Contact by PCOEMHS and will be returned by each jurisdiction within a minimum of three weeks. The questionnaire will be comprised of the following questions:
    - **Hazard Identification:** Have the risks and hazards changed?
    - **Goals and objectives:** Are the goals and objectives still able to address current and expected conditions?
    - **Mitigation Projects and Actions:** Has the project been completed? If not complete but started, what percent of the project has been completed? How much money has been expended on incomplete projects? Did the project require additional funds over the expected amount or were the costs less than expected?

During the annual meeting, each jurisdiction will have the opportunity to provide a report to the group summarizing its review of the Plan. The report will include their responses to the above questions and any other items specific to their community. Documentation of the annual meeting will include notes on the results of the meeting as well as more specific information on the reasoning for proposed changes to the Plan for the next update cycle. Copies of the annual review report will also be included in Appendix E.

A formal presentation of the status of the goals, objectives and A/Ps will be made to each jurisdiction's board or council following the review meeting. The action will be informational only and will not require a formal action on the part of the board or council unless a major update to the Plan is proposed prior to the next five year update.

Monitoring of Tribal Mitigation Activities

This section describes the Pascua Yaqui Tribe's strategy for reviewing and assessing the progress of the mitigation goals and actions/projects (A/Ps) identified in this Plan.

Unless otherwise directed or warranted, the goals and objectives' review will coincide with the annual overall plan review and update schedule. Goals will be assessed using a subjective approach and a summary of the assessment will be included in the annual review memorandum.

The A/Ps and the corresponding implementation strategies for the Pascua Yaqui Tribe are identified in the Plan's mitigation strategy. For each annual review and plan update, the Pascua Yaqui Tribe will coordinate with the agencies identified for each A/P, to assess the implementation status of the identified A/P and generate a brief memorandum summarizing the status of each project using the following criteria:

Current Status of Action/Project - Assign a 'No Action', 'In-Progress' or 'Completed' status as appropriate

Project Disposition – Assign a 'Keep' or 'Drop' to identify future disposition of action/project

Explanation - Provide a description of the current project status including date of implementation, challenges faced, percentage completed, funding sources used, etc.

The implementation and progress of the A/Ps will be monitored by the Pascua Yaqui Tribe on at least an annual basis as described in Section 7.1.1. For FEMA supported projects, progress reports will be submitted to FEMA on a quarterly basis, or as required throughout the project duration. The degree of quarterly reporting will be dependent upon the type of A/P, its funding source, and the associated requirements. At a minimum, the quarterly report shall address:

- Project Completion Status
- Project Challenges/Issues (If any)
- Budgetary Considerations (Cost Overruns or Underruns)
- Detailed Documentation of Expenditures

Upon completion of projects, the project location will be visited and final results viewed and documented. Closed projects will then be monitored for effectiveness in the intended mitigation. FEMA supported project closeouts will include an audit of the A/P financials as well as other guidelines/requirements set forth under the funding or grant rules, and any attendant administrative plans developed by the Pascua Yaqui Tribe.

The Plan requires updating and approval from FEMA every five years. The plan updates will adhere to that set schedule using the following procedure:

- One year prior to the plan expiration date, the Planning Team will re-convene to review and assess the materials accumulated in Appendix E.
- The Planning Team will update and/or revise the appropriate or affected portions of the plan and produce a revised plan document.
- The revised plan document will be presented before the respective councils and boards for an official concurrence/adoption of the changes.
- The revised plan will be submitted to ADEM and FEMA for review, comment and approval.

6.3 Incorporation into Other Planning Mechanisms

Incorporation of the Plan into other planning mechanisms, either by content or reference, enhances a community's ability to perform hazard mitigation by expanding the scope of the Plan's influence. A poll of the participating jurisdictions revealed that success of incorporating the 2007 Plan elements over the past planning cycle into other planning programs has varied. Ways in which the 2007 Plans have been successfully incorporated or referenced into other planning mechanisms for each jurisdiction are summarized below:

Past Activities

Pima County

- The 2007 Plan is cited in the Annual Recertification and 5-yr Cycle Verification of the Community Rating System.
- Referenced during the following processes; Comprehensive Plan Amendment, Rezoning, and Basin or River Management Planning efforts.
- Used as reference material for the update of the Pima County Emergency Operations Plan

Marana

- Used by the Town of Marana during the update of the Emergency Operation Plan beginning in March 2010.
- Used as a reference for identifying of natural and man-made hazards in the Town's General Plan..

Oro Valley

- Used by the Town of Oro Valley during the update of the Emergency Operations Plan, beginning in September 2010.
- Used by the Town of Oro Valley during the development of other emergency plans (such as evacuation plans, Standard Operating Procedures, shelter in place programs, public outreach opportunities, etc.), beginning in September 2010.
- Used as a reference for the profiling of natural and man-made hazards as referenced in the Town's General Plan.
- Used as a reference for hazards mentioned in the Open Space and Natural Resource Conversation section of the Town's General Plan.
- Some of the 2007 Plan mitigation A/Ps correlate to the Town's Capital Improvement Projects program

Pascua Yaqui Tribe

- None Provided

Sahuarita

- No specific references or incorporation of the 2007 Plan was reported by Sahuarita. However, hazard mitigation has been historically referenced in the 2004 Town of Sahuarita Emergency Operations Plan and Town Code Chapter 13.20.040

Tucson:

- Used as reference material for the update of the 2006 Emergency Operations Plan
- Referenced by Tucson Intranet and in the Tucson Office of Emergency Management and Homeland Security Newsletter.

In all of the above instances, the 2007 Plan was found to be beneficial, and especially with regard to the critical facility inventories, vulnerability analysis results, and the mitigation strategy. Obstacles to further incorporation of the 2007 Plan for some of the communities were generally tied to:

- A lack of awareness of the 2007 Plan by departments outside the emergency management community
- The relative "newness" of the 2007 Plan with regard to other, more commonplace planning mechanisms

such as comprehensive or general plans.

- No real opportunity for incorporation of reference of the 2007 Plan (e.g. – very little other planning being done by a community).

Future Activities

Pima County

-

Marana

-

Oro Valley

-

Pascua Yaqui Tribe

-

Sahuarita

-

Tucson

-

South Tucson

-

Typical ways to use and incorporate the Plan over the next five-year planning cycle, discussed by the Planning Team, included:

- Use of, or reference to, Plan elements in general and comprehensive planning update documents.
- Addition of defined mitigation A/Ps to capital improvement programming.
- Inclusion of Plan elements into development planning and practices.
- Resource for developing and/or updating emergency operations plans.

The Plan will continue to function as a standalone document subject to its own review and revision schedule presented in Sections 7.1 and 7.2. The Plan will also serve as a reference for other mitigation and land planning needs of the participating jurisdictions. Whenever possible, each jurisdiction will endeavor to incorporate the risk assessment results and mitigation actions and projects identified in the Plan, into existing and future planning mechanisms. At a minimum, each of the responsible agencies/departments noted in Tables 6-1-1 through 6-1-6 will review and reference the Plan and revise and/or update the legal and regulatory planning documents, manuals, codes, and ordinances summarized in Tables 6-1-1 through 6-1-6, as appropriate. Specific incorporation of the Plan risk assessment elements into the natural resources and safety elements of each jurisdictions' general plans (county comprehensive plan) and development review processes, adding or revising building codes, adding or changing zoning and subdivision ordinances, and incorporating mitigation goals and strategies into general and/or comprehensive plans, will help to ensure hazard mitigated future development. In addition, an implementation strategy outlining assignments of responsibility and completion schedules for specific actions/projects proposed in this plan are summarized in Tables 6-9-1 through 6-9-6.

Table 7-1 presents a list of current planning efforts for the Pascua Yaqui Tribe that are either related to, referenced in, and/or are parallel to this Plan. It is the Pascua Yaqui Tribe's intention to integrate information as described below to ensure correlation of common planning elements.

Table 6-1: Pascua Yaqui Tribe planning efforts for future integration

Document	Description	Integration Characteristics/Mitigation Opportunities	Author / Owner
Pascua Yaqui Tribe's Master Land Use Plan	The objective the master land use plan is to provide a current document that reflects the growth and changing needs of the Pascua Yaqui pueblo, serves as a guide for decision makers. This plan was adopted in 2004.	• Minimize incompatible land uses • Provide a balance of land uses that preserves and enhances the neighborhood, support in-fill strategies, promote economic development, and protect environmentally and culturally significant resources. • No planned area development project will be allowed within 200 feet of any waterway.	The Planning Center Pascua Yaqui Tribe
Master Drainage Study for Pascua Yaqui Tribe Reservation	The master drainage study/ is a critical component to the Tribe's economic well being, as well health, safety and general welfare of the community. This plan was adopted in 2004.	• Minimize the flooding and drainage problems • No development zones set aside for conveyances of floodwaters • Construct regional storm water retention facilities	Tetra Tech, Inc. Pascua Yaqui Tribe
Zoning Ordinance	The Tribal Council is considering adopting a zoning ordinance to regulate and encourage the most appropriate uses of land. This plan is currently pending council approval.	• Reduce the effects of natural hazards on life, property, and infrastructure, • Require pre-development and post-development hydrology and proposed storm water management or drainage mitigation	The Planning Center Pascua Yaqui Tribe
Public Health and Emergency Preparedness Response Plan	Addresses response and preparedness regarding public health issues and outbreaks. Identifies mitigation measures to reduce the spread of disease. This plan was last approved in 2007 and is currently in the process of being updated.	• Used for mitigation of outbreaks on an interagency basis. • Interagency awareness and communication. • Source for Disease related	PYT Public Health and Emergency Preparedness and Pima County Health Dept. Jointly owned between PYT and Pima County

APPENDIX A: PLAN TOOLS

Acronyms

ADEM .....Arizona Division of Emergency Management
ADEQ .....Arizona Department of Environmental Quality
ADWR .....Arizona Department of Water Resources
AGFD .....Arizona Game and Fish Department
ARS .....Arizona Revised Statutes
ASCE .....American Society of Civil Engineers
ASERC .....Arizona State Emergency Response Commission
ASLD .....Arizona State Land Department
ASU .....Arizona State University
AZGS .....Arizona Geological Survey
BLM .....Bureau of Land Management
CAP .....Central Arizona Project
CAP .....Community Assistance Program
CFR .....Code of Federal Regulations
CRS .....Community Rating System
CWPP .....Community Wildfire Protection Plan
DEMA .....Arizona Department of Emergency and Military Affairs
DFIRM .....Digital Flood Insurance Rate
DMA 2000 .....Disaster Mitigation Act of 2000
DOT .....Department of Transportation
EHS .....Extremely Hazardous Substance
EPA .....Environmental Protection Agency
EPCRA .....Emergency Planning and Community Right to Know Act
FEMA .....Federal Emergency Management Agency
FMA .....Flood Mitigation Assistance Grant Program
GIS .....Geographic Information System
HAZMAT .....Hazardous Material
HAZUS-MH .....Hazards United States Multi-Hazard
IFCI .....International Fire Code Institute
LEPC .....Local Emergency Planning Committee
MMI .....Modified Mercalli Intensity
NCDC .....National Climate Data Center
NDMC .....National Drought Mitigation Center
NESDIS .....National Environmental Satellite, Data and Information Service
NFIP .....National Flood Insurance Program
NFPA .....National Fire Protection Association
NHC .....National Hurricane Center
NIBS .....National Institute of Building Services
NID .....National Inventory of Dams
NIST .....National Institute of Standards and Technology
NSF .....National Science Foundation
NOAA .....National Oceanic and Atmospheric Administration
NRC .....National Response Center
NWCG.....National Wildfire Coordination Group
NWS .....National Weather Service
PAG .....Pima Association of Governments
PCOEMHS .....Pima County Office of Emergency Management and Homeland Security
PCRFCD.....Pima County Regional Flood Control District
PSDI .....Palmer Drought Severity Index
RL .....Repetitive Loss
SARA .....Superfund Amendments and Reauthorization Act

SRLP .....Severe Repetitive Loss Properties
SRL .....Severe Repetitive Loss
SRP .....Salt River Project
UBC .....Uniform Building Code
USACE .....United States Army Corps of Engineers
USDA .....United States Department of Agriculture
USFS .....United States Forest Service
USGS .....United States Geological Survey
VA .....Vulnerability Analysis
WUI .....Wildland Urban Interface